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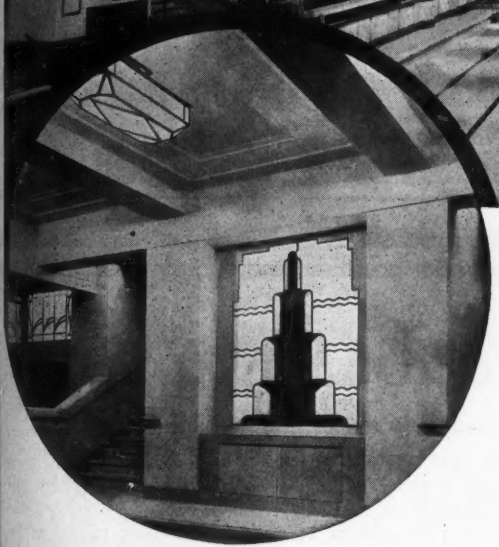

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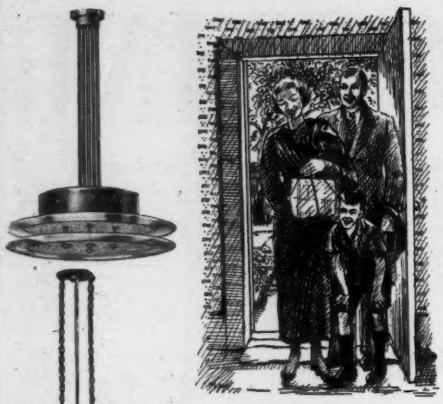

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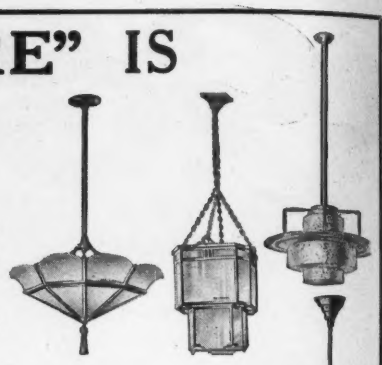

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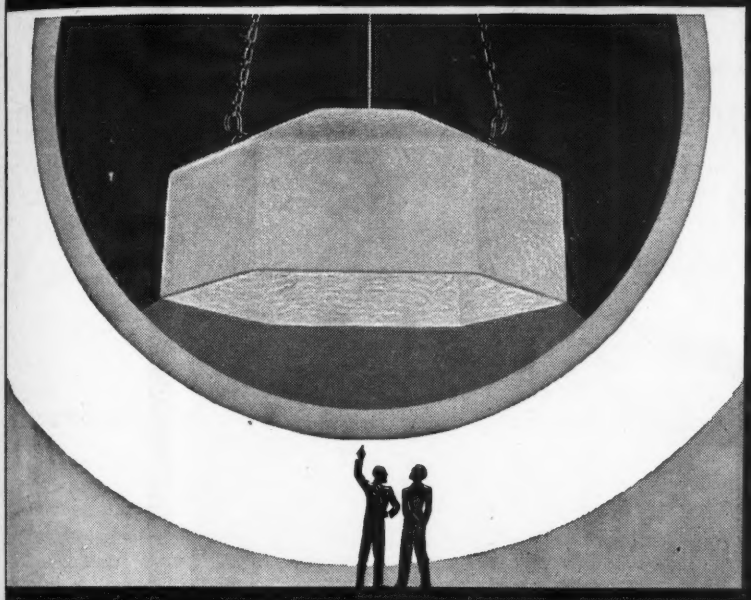

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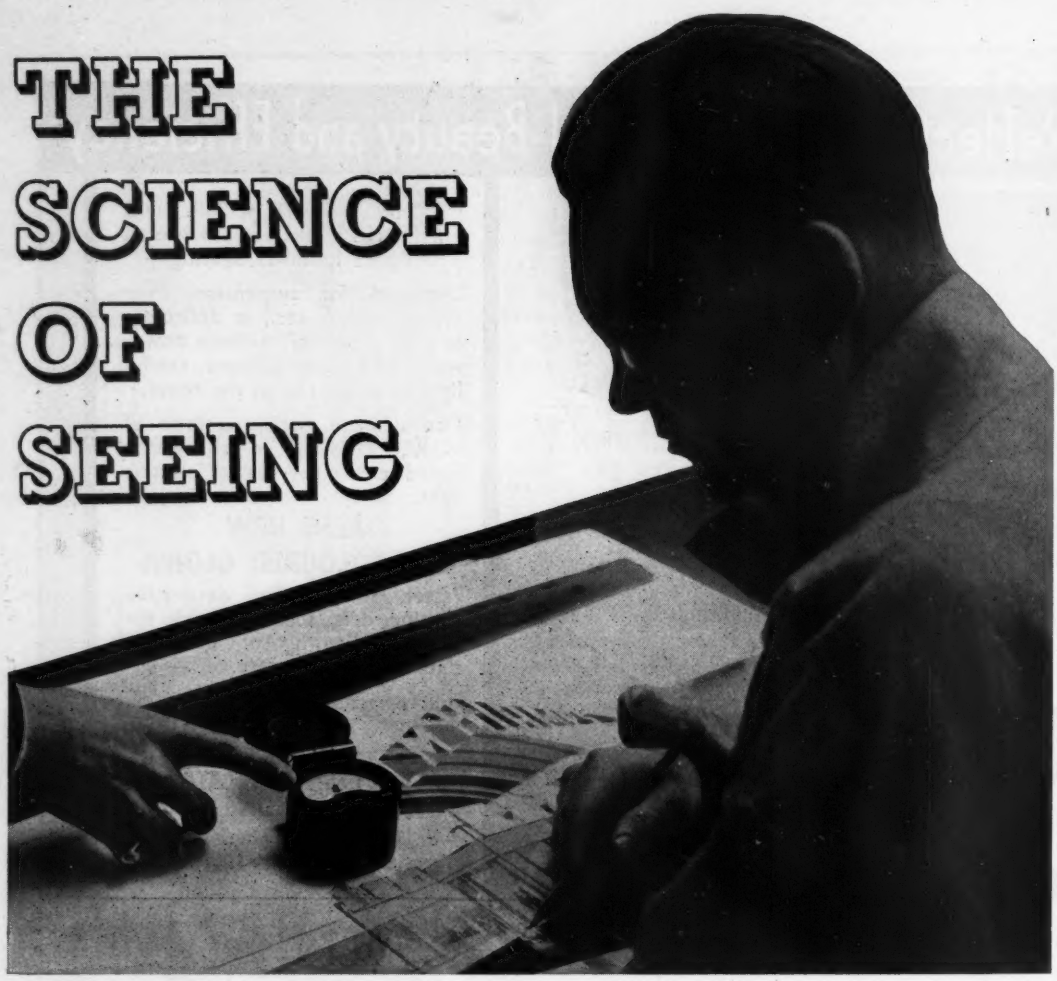

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The ILLUMINATING ENGINEER

THE JOURNAL OF GOOD LIGHTING

Edited by

J. STEWART DOW

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Make Your Meaning Clear

THOSE Who Preach the Gospel of Better Lighting have one obvious duty—to make it perfectly clear what they mean by better lighting.

Sometimes ideas cannot be easily communicated by words alone. The saying that example is better than precept is no doubt specially applicable to lighting. If people can experience for themselves how higher illuminations lead to quicker and clearer vision, how the glare from lights misused causes discomfort and impairs power of perception, this will save much verbal explanation.

Equally important is the choice of symbols and graphic methods whereby ideas about lighting can be quickly presented and understood. For this reason such attempts as the method of portraying distribution of illumination suggested by Mr. Holmes in our last issue, and such artifices as the use of models in illuminating engineering so fully described by Mr. Barlow in this number are well worth study.

Explanations of lighting effects should be reinforced by an appeal to the eye. There is a great deal to be learned yet about the art of demonstration in illuminating engineering!

The Jubilee Floodlighting

Now that the Jubilee celebrations are past, it may be interesting to record one or two impressions of the floodlighting, fully illustrated in our last issue. It happened, very fortunately, that the lighting synchronised with a period of exceptionally fine weather. The natural floodlighting afforded by the rays of the setting sun was unusually good. On one evening at least, the mellow glow of Westminster Tower was quite reminiscent of the afterglow familiar in mountainous districts abroad. During the brief interval after sunset when this glow still persisted, and the illuminated towers and pinnacles were seen with a deepening blue sky as a background, the effect of artificial floodlighting was at its best—surely much more pleasing and artistic than the subsequent more striking contrast against a black sky. One was made to realise that this factor —the absence of light in the sky—is the main one in causing the unnatural "pasteboard" effect of which architects occasionally complain. One successful element in many installations was the use of concealed lighting to reveal columns, etc., in silhouette —the spire of St. Mary-le-Bow (Cheapside) was a pleasing instance of this method.

The Use of Coloured Light

One other feature, the use of coloured light, was of more problematical advantage. The view that vivid and theatrical colour floodlighting should not be applied in the case of buildings of national and historic interest is doubtless correct, though a delicate tinting of light (such as is associated with artificial daylight effects) might sometimes be permissible. One could not help feeling, however, that in the case of buildings to which this objection could not apply, e.g., those of a commercial character, the possibilities of colour harmonies and contrasts had not been fully realised. In some cases where combinations of coloured light was attempted, e.g., when the main part of a building was illuminated with white light and certain projecting parts in red or green, the effect was oddly grotesque. Certainly, there is much to be learned in regard to this phase of floodlighting.

Modern Street Lighting

In a paper recently read before the E.P.E.A. London Technical Group, Mr. W. J. Jones pointed out that a car travelling at sixty miles per hour needed nearly 300 feet in which to pull up. Therefore, the motorist should be able to see things clearly at this distance ahead. Objects on artificially lighted roads are revealed mainly in silhouette. A compromise between elimination of glare and high road brightness (necessitating light emitted almost horizontally) is only feasible with mounting heights of twenty-five to thirty feet. An ideal road surface should have high road reflection when wet as well as dry—an ideal approached in certain granite sets studied by Mr. Langlands. After dealing with the requirements of different classes of roads, Mr. Jones referred to recent advances in the uniformity and quality of electric lamps. Ordinary gas-filled lamps give twenty-five per cent. more light during life than was obtainable ten years ago. He quoted the case of a London Borough which decided to scrap all lamps after 1,100 hours' burning. In 1931, 7,000 were thus replaced before failure during the day; 6,000 failed in service and had to be replaced by night. In 1932, however, a marked improvement ensued, and last year only 600 lamp failures took place at night, rendering possible a twenty-five per cent. reduction in the maintenance staff and an annual saving of £300. In conclusion, the author gave the approximate cost per mile of lighting according to Classes C to G in the specification. A good standard of lighting, with all night burning, need not cost more than about £300 per mile per annum—which is considerably less than the cost of maintaining such roads.

Practical Considerations in Architectural Lighting

By H. LINGARD, A.M.I.E.E.

(Paper read at the meeting of the Illuminating Engineering Society held at the Institution of Mechanical Engineers, Storey's Gate, St. James's Park, London, S.W.1, at 6.30 p.m., on Tuesday, April 9th, 1935.)

Introduction.

Architectural Lighting may be defined as a system of lighting which utilises luminous or illuminated surfaces as an essential part of the building design, and where the requisite lighting equipment is either built-in or on-to the structure as an integral part thereof. It differs from ordinary methods of lighting in much the same way as a tailor-made garment differs from a ready-made; it has to be specially fashioned to suit each particular case. To the average person its aesthetics are obscure, and hard and fast rules cannot be laid down easily, as a guide to ensuring a pleasing effect.

The practical difficulties with which the Illuminating Engineer has to cope are, however, very tangible, and the object of this short paper is to describe a few experiments undertaken by the Lighting Service Bureau for the Architectural Lighting Sub-Committee of the N.I.C. dealing with the engineering aspects of the subject.

Architectural lighting, as defined above, is not, of course, new; concealed lighting systems have existed since the earliest days of the electric lamp; but whereas a few years ago architectural lighting was the exception, it is apparent to-day that a very substantial number of new lighting installations are of this type. The situation is analogous to road accidents; they have always happened, but have intensified of late to such an extent that prompt action must be taken.

I do not wish to infer that the position is in any way regrettable; indeed, the lighting industry has rarely cultivated a more promising plant. It is most essential, however, that we should tend it with the utmost care, even if we are not always to be held responsible for the results when it bursts into bloom!

For ordinary lighting, the manufacturer markets a limited range of well-tried, self-contained devices which are more or less fool-proof. These are installed in a standard manner, i.e., hanging from the ceiling, and satisfactory technical performance is assured. In designing a standard range of fittings the following factors, among others, are fixed: *brightness, luminous efficiency, temperature rise, ventilation, and accessibility.*

With architectural lighting, on the other hand, there can be little standardisation of lighting equipment, and it is not surprising that technical errors are liable to occur, particularly as the equipment for such installations is not always manufactured by experienced fittings designers.

It is a well-known fact that architectural lighting usually necessitates a higher current consumption for a given illumination, and many of us are now thinking in terms of 5 watts per square foot instead of 1 watt per square foot as heretofore. This comparatively low co-efficient of utilisation is, however, justified, since the criterion of an architectural lighting installation is effectiveness rather than efficiency. The inherent costliness of architectural lighting is not, however, any excuse for bad engineering. The fact that 75 per cent. of the light is lost in a given architectural lighting installation due to the location of the light source and the peculiar distribution of the light flux is no reason why lack of suitable reflectors and bad lamp positioning in the fitting itself should be allowed to reduce the overall co-efficient of utilisation still further.

If one attempts to tabulate common engineering faults in architectural lighting installations, the order of importance works somewhat as follows:—

1. Low luminous efficiency of fittings.
2. Spottiness of light on luminous surfaces.
3. Rapid depreciation of light due to dust collection.
4. Inaccessibility for cleaning and lamp renewal.
5. Excessive temperature rise.

The above are faults of engineering, and concern us directly; the placing, colour, and shape of the lighting elements may be equally objectionable, but, being aesthetic matters, do not worry us here.

Experimental Work.

General Characteristics.—As a guide to the characteristics of a typical architectural lighting installation an investigation was carried out on a flush laylight in a committee room, this being considered a satisfactory installation from the point of view of appearance and performance. A view of the room is

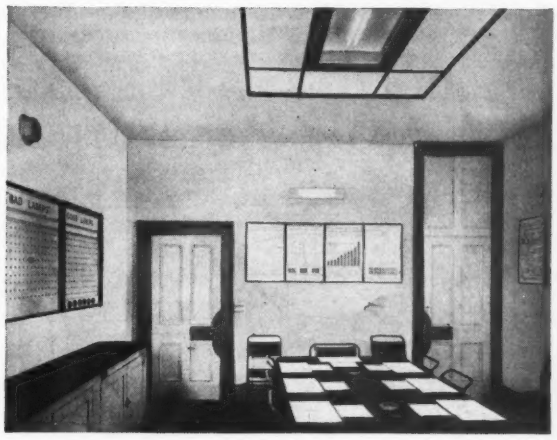
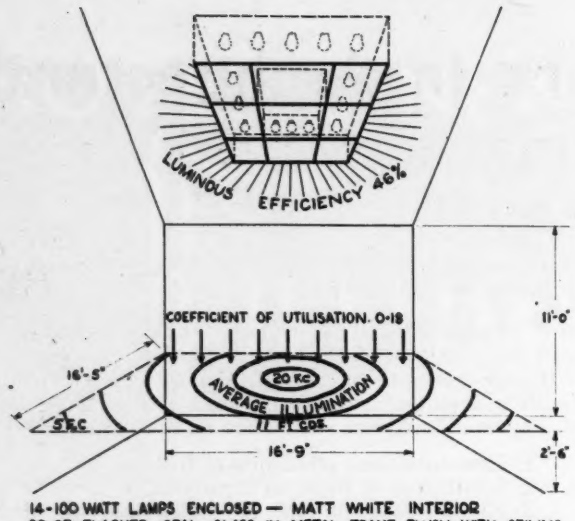


Fig. 1.

shown in the Figure 1 and the test results in Figure 2. The investigation was carried out under "service" conditions, i.e., five weeks after cleaning and lamp renewal.

The lighting equipment was dust-tight, and it will be noted that no special reflectors were employed, reliance being placed on a good matt white finish on the inside surfaces of the lamp boxes. It will be seen that an average illumination of 11.3 foot-candles was provided, with a co-efficient of utilisation of 0.18, the wattage per square foot being 5.3. This illumination is in accordance with present day recommendations, while a uniformity of 25 per cent. $\left(\frac{\text{Minimum foot-candles}}{\text{Maximum foot-candles}}\right)$ is not considered excessive for a room of this character. The brightness uniformity of the glass is of a high order, the surface appearing equally bright all over.

When are Reflectors Worth While?—In discussing the characteristics of the above installation, one par-



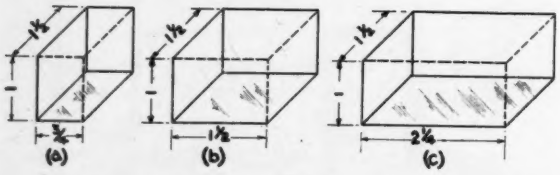
14-100 WATT LAMPS ENCLOSED — MATT WHITE INTERIOR
22 OZ FLASHED OPAL GLASS IN METAL FRAME FLUSH WITH CEILING
AREA OF GLASS - 25 SQ. FT. — CEILING - WHITE — WALLS - SALMON PINK
REFLECTION FACTOR - 44% — AREA OF WORKING PLANE 263 SQ. FT.
— WATTS PER SQ. FT. - 5·3.

Fig. 2.

ticular line of research was clearly worth following up, namely, whether reflectors on the lamps would improve the luminous efficiency and hence increase the coefficient of utilisation. It was considered that the proportions of the space above the laylight might have an important influence on the contributed light from reflecting equipment, and accordingly an investigation was carried out with three sets of proportions, keeping the distance of height from glass to ceiling or top limit constant. These proportions are shown in Figure 3.

In order to extend the usefulness of the investigation the following two kinds of interior surfaces were used:—

1. All inside surfaces matt white (Reflection Factor 73 per cent.).
2. All inside surfaces matt black (Reflection Factor 3 per cent.).



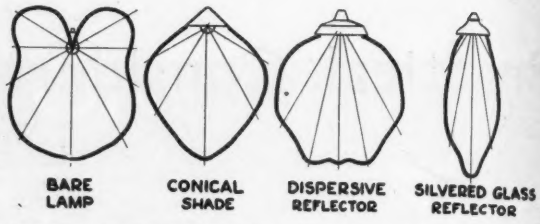
PROPORTIONS OF EXPERIMENTAL LAYLIGHTS

Fig. 3.

The former representing boxed in laylights and the latter the open type where no actual ceiling or walls exist.

Four types of lighting equipment were employed, namely, bare pearl lamps, conical iron shades, Standard Dispersive Industrial Reflectors, and Concentrating Silvered Glass Reflectors. The outline and approximate polar curve of each of these sources is shown in Figure 4. These light sources were installed so that visual uniformity of brightness was obtained over the 22-oz. flashed opal glass with which the experimental laylight was glazed. For each set of conditions lumeter readings were taken of the brightness of the opal glass. Small elements of the glass were measured successively by the employment of a template which exposed one square inch of the glass at a time. Six such readings were taken per square foot of glass.

Tables I. and II. show the results and represent conditions for boxed-in and open laylights respectively.



LIGHTING EQUIPMENT USED IN EXPERIMENTAL LAYLIGHT
(POLAR CURVES NOT TO SCALE)

Fig. 4.

Table I. Experimental Laylight—Interior Finish Matt White.

Proportions	Bare Lamps L. Effy.	Conical Iron Shades		Standard Dispersive Reflectors		Silvered Glass Reflectors	
		L. Effy.	% Increase on Bare Lamp Efficiency	L. Effy.	% Increase on Bare Lamp Efficiency	L. Effy.	% Increase on Bare Lamp Efficiency
A.	46	43	−12%	45	5.5%	53	17%
B.	60	47	−20%	52	−13.5%	61	18%
C.	64	55	−29%	60	−5.2%	70	10%

Table II. Exterior Laylight—Interior Finish Matt Black.

Proportions	Bare Lamps L. Effy.	Conical Iron Shades		Standard Dispersive Reflectors		Silvered Glass Reflectors	
		L. Effy.	% Increase on Bare Lamp Efficiency	L. Effy.	% Increase on Bare Lamp Efficiency	L. Effy.	% Increase on Bare Lamp Efficiency
A.	8.5	21	150%	24	185%	31	269%
B.	15.5	32	108%	40	160%	38	147%
C.	18.0	33	78%	42	131%	37	103%

The inference to be drawn from Table 1 can be stated as follows:—*For shallow boxed-in laylights finished white on the inside and glazed with flashed opal glass, there is no advantage in using reflecting equipment with the lamps, unless such equipment has a very concentrating distribution and a high luminous efficiency.*

Whether the increase in luminous efficiency of 17 per cent. by using concentrating reflectors with the proportions (a) is worth while will depend on the economics of the situation. For example, with electricity at 6d. per unit the reflector will pay for itself in about 2,000 hours, on account of the saving it effects. This means about two years with three hours' operation per day; with electricity at a penny per unit the period would be extended to twelve years, which is approaching the useful life of the reflector and makes the use of this equipment only just worth while.

Table 2 puts an entirely different complexion on the matter, since it shows that even the despised conical iron shade will more than double the overall efficiency in two out of the three proportions, while the better-class reflectors show much more substantial improvements.

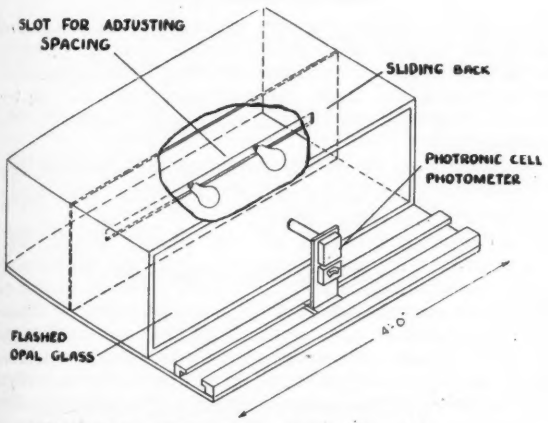
From the test it can be recommended that:—*For laylights which are not boxed in or finished in light colours, efficient reflecting equipment should be employed, as it has a marked influence on the overall efficiency of the feature. Preference should be given to reflectors which direct the light flux mainly on to the glass surface.*

THE SPACING OF LIGHTING EQUIPMENT TO AVOID SPOTTINESS.—It has been mentioned that one of the most common faults in the design of architectural lighting installations is the inequality of brightness produced on luminous surfaces due to faulty spacing of the lighting equipment. It is not suggested that brightness uniformity is a universal ideal; there are

cases where spottiness working in with patterning on the glass adds appreciably to the effect. Such examples, however, usually employ frosted or acid-etched glass, but where translucent opal glass is employed, the aim is generally to achieve uniformity of brightness, or at any rate to avoid sudden transitions of brightness which reveal to the observer the whereabouts of the lamps.

At first sight, the problem of illuminating the inside surface of a luminous architectural lighting element so that uniform brightness is obtained on the other side, appears susceptible of solution by the application of ordinary spacing-mounting height ratios. In practice this does not work out satisfactorily on account of the fact that with wide spacing of equipment light rays strike the surface of the glass at high angles of incidence and a large proportion are back-reflected in consequence. In other words, uniformity of illumination on one side of a diffusing glass does not always imply uniformity of brightness on the other.

In order to substantiate the general experience referred to above, an investigation was undertaken to ascertain the requisite spacing of bare lamps and reflectors in relation to their distance behind flashed opal glass in order to provide uniform brightness over the latter. The apparatus employed was of the form and dimensions shown in Figure 5, both the distance



APPARATUS USED FOR LAMP SPACING EXPERIMENTS.

Fig. 5.

of the lighting equipment from the glass and its distance apart being variable. The light box was finished matt white on the inside and was completely enclosed during each test. Readings of brightness were taken in this case by a photo-voltaic photometer with a special front attachment as shown in the fifth illustration.

The procedure consisted of fixing the spacing of the lighting equipment and then varying its distance behind the glass until there was no beat on the instrument needle when the cell was moved across the glass surface from light centre to light centre, i.e., when uniform brightness was achieved. Light centre spacings of from 3 inches to 26 inches were tested for the same four types of lighting equipment used in the laylight efficiency investigation, namely, bare pearl lamps, conical iron shades, Standard Dispersive Industrial Reflectors and Concentrating Silvered Glass Reflectors.

The results derived are shown by the curves in Figure 6, from which it will be seen that, except for silvered glass reflectors, the equipment all approximates to the straight line law ratio of 1 to 1. In other words, the brightness uniformity appears to be independent of the type of reflecting equipment employed, being the same for lamps without reflectors as for lamps with, the only exception to the

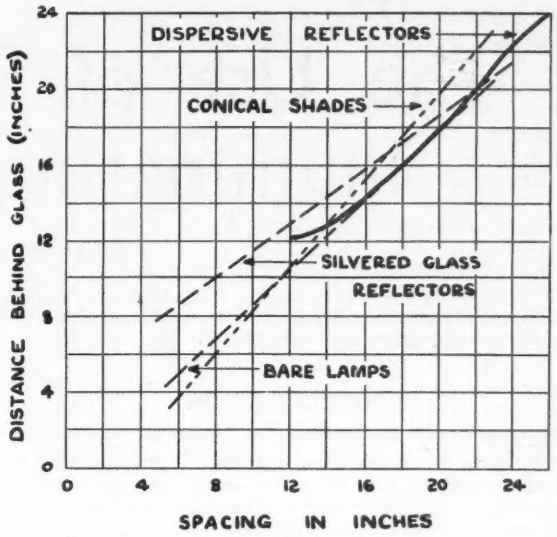


Fig. 6.

above being for reflectors with a very concentrating distribution.

From the above results the following recommendation seems reasonable:—

That for uniform brightness over boxed-in architectural lighting features glazed with flashed opal glass, the lighting equipment if placed in a single line should be so arranged that the lamp centres are a distance apart equal to their distance from the glass.

Conclusion.

It is obvious that the few investigations referred to in this paper represent merely a start on a very large piece of work. There is great scope for experiment on the subject of depreciation, accessibility, and temperature rise of architectural lighting equipment, and perhaps the findings recorded here may inspire other and more comprehensive research work, while for the time being they may serve as a useful guide to the practising designer of this new and interesting form of lighting equipment.

Street Lighting and its Relation to the Safety of Roads

A very successful joint Conference of the Illuminating Engineering Society and the Association of Public Lighting Engineers was held in connection with the National Safety Congress in London on May 31. Sir John Pybus (late Minister of Transport) took the chair and there was an excellent audience.

In introducing his subject Mr. Langlands emphasised the necessity of legislation compelling effective lighting of built-up areas. The "may" in existing legislation should be changed to "shall." He quoted from the Act relating to the City of Glasgow, which not only ensured the provision of lighting but also its proper maintenance. In a National Scheme, the author suggested, the first aim should be to get good lighting in towns and cities—so good that it could be made an offence for a motorist to use a headlight. In regard to methods of public lighting he advised those responsible to "go high, have big units, and as little directional gear as possible." In the concluding portion of his paper Mr. Langlands showed some pictures illustrating the appearances of streets under wet and dry conditions and made effective use of a picture from "The Sketch" showing the value of contrast in relation to visibility.

[We hope to include a fuller account of the paper and of the ensuing discussion in our next issue.—ED.]

The Use of Scale Models in Illuminating Engineering

By H. S. BARLOW, M.Sc.

(This paper, presented at the meeting of the Illuminating Engineering Society held at the Institution of Mechanical Engineers, Storey's Gate, St. James's Park, London, S.W.1, at 6.30 p.m., on Tuesday, April 9th, 1935, is based on the Investigations conducted for the Technical Committee of the Society by the Panel consisting of:—Mr. A. W. Beuttell, Mr. H. Buckley, Mr. H. S. Barlow, Mr. M. W. Peirce, Mr. A. M. Turing and Mr. J. M. Waldram.)

INTRODUCTION

Learning by seeing plays an important part in our daily life. It enables us to grasp a thought with the least expenditure of time and energy. This is especially true wherever the principles of good lighting practice are to be recognised or explained.

It is difficult to plan an installation from a simple drawing of the locality to be lighted. Many of the variables which enter into the problem have uncertain effects and it is difficult to make allowances for them on paper. Even the convenient tabular data which are now available for the planning of interior lighting schemes* were obtained from practical experiments in rooms specially constructed for the purpose.

In many illumination problems the use of a practical model of the lighting scheme is the most reliable method of predicting the final performance. By these means, the illumination, the size of lamps, and the spacing can be studied and the effects of reflections from decorations determined. Further by such a demonstration the effects of direct glare, specular reflection, shadows and efficiency become real and no longer abstract. This is equally true in the cases of artificial lighting and day-lighting of interiors, street lighting, flood lighting, sign lighting, interior decorative lighting, and even in the case of the adjustment of vehicular lights and the lighting of street signals.

The application of scale models to the solution of technical problems has been, and is still being, widely used. It has the advantage of three dimensional work over the pictorial, and has a mobility that is unrivalled, as well as being so much simpler, in the case of the problem of the predetermination of illumination, than direct calculation or graphical methods of solving the problems.

Much investigatory work has been carried out upon models and numerous problems have been solved by their aid. The literature describing the work is, however, scattered, and it is the aim of this paper to summarise what has already been published in order that it may be readily available for reference.

Whenever possible it is obviously desirable that the model should be full scale, as in such cases the sources, which are the main detail to be considered, can be exactly reproduced. However, when this is impossible by reason of the limitations of the space available, a diminution in the scale must be applied. In this case, the problem which now concerns us is as follows. To what extent should the scale be reduced to give us a full appreciation of the final results as reproducible on the full scale? To what extent can the details of the full scale subject be reproduced in the model by means of the standardised sources available?

If it were possible to reproduce correctly the characteristics of the sources, fittings, and room furniture the problem would be a simple one. However, for the purpose of rendering scale models available for universal use it is desirable that we should use those standardised sources available, or that manufacturers should introduce model sources to assist in this matter.

The problem divides itself automatically into three distinct sections: (a) artificial lighting of interiors, (b) natural lighting of interiors, (c) exterior artificial lighting, such as flood lighting, street lighting, airport lighting, lighting of playing fields, etc. The attempts to solve particular and general problems which have so far been made will be considered in each of the above three sections.

Choice of Scale (1).

In order to form a correct assessment of a lighting system by the use of models, since if the same brightnesses are to be reproduced the brightness gradients are increased, the scale ratio chosen must not be too small. The scale is chosen mainly according to the factors:—

(a) the type of lighting system to be reproduced,
(b) the possibility of diminishing the model sources in the same ratio.

If incandescent lamps of the public supply volt ranges are to be used, which would be extremely useful, a suitable scale (2) is 1:4 for normal interiors, whilst for larger rooms 1 : 5 is convenient. However, for exterior demonstrations it is impossible to use such scales. In street models the scale must be much smaller, since as large an amount of the system as possible must be demonstrated. The street model in the Osram Licht-Haus, Berlin, is made to a scale of 1 : 25. The model is 64 cm. broad, which corresponds to 16 metres in the real street. The areas are sufficient in such a case to be able to judge the characteristic properties of the lighting system employed.

If the model is of linear dimensions λ times that of the full scale installation, the following reductions should be made in the candlepower of the model light sources:—

(1) Point sources, candlepower $\times\lambda^2$.
(2) Line sources, length $\times\lambda$; breadth $\times 1$, candlepower $\times\lambda^2$.
i.e., candlepower per unit length $\times\lambda$.
(3) Extended sources, length $\times\lambda$; breadth $\times\lambda$, candlepower $\times\lambda^2$,
i.e., brightness $\times 1$.

Hence the correct intensity of illumination can be effected by diminishing the light output of the full-scale sources used by the square of the scale, e.g., with 1 : 4 scale the light output scale is 1 : 16.

It is important that all fittings and furniture should be correctly produced to scale, and since the form of objects is determined by their brightness, it is of great importance that the surface characteristics, both in degree and type of reflection, should be exactly copied, as also should their inclination. This latter factor is important, since it governs not only the nature of the shadows but also the surfaces' own intensities of illumination and the redistribution of the light.

The reproduction of the kind of reflection is usually simple for interiors, but for exteriors this is not

* Harrison and Anderson. Am. Illum. Eng. Soc.: Trans., 1920, p. 97, and E.L.M.A. Handbook No. 2C.

the case, as, in the street model, the type of reflection is influenced by weather conditions, and it is advisable in such circumstances to copy each type. It is also obvious that the illumination due to shop windows and signs should be taken into account in a street model.

In order to assess the model lighting system, the model must be viewed as nearly as possible from the position of the scaled observer, and as the adaptation of the eye influences the impression, it is necessary to take precautions for abolishing foreign disturbing light so that only the light sources of the model can produce any effect. On the other hand, no light source

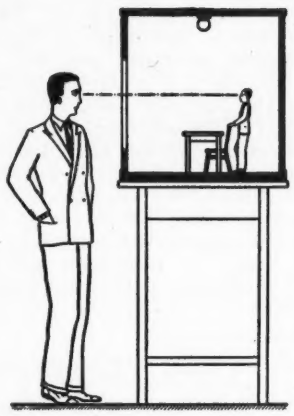


Fig. 1. Indicating Position of observer relative to scale model.

must be omitted which may alter the adaptation of the eye. This refers mainly to exterior lighting systems, where signs, etc., may influence considerably the whole street illumination. On the other hand, the entrance of daylight especially may cause partial vanishing of the model light sources.

Interior Artificial Lighting.

The question of the faultless reproduction of lighting effects in model rooms has been studied by means of extensive experiments carried out at the Institute of Lighting Technology[3] in Karlsruhe. The results of these experiments have been compared with measurements in normal-sized rooms and have shown that with suitable choice of the sources, the average illumination in the model rooms comes very close to those of the original, the error being never greater than 3 per cent. However, this does not apply to comparisons between the equality of illumination at two corresponding points. The following are some of the results obtained:—

The sources were photometered to find the total flux emitted and also to obtain the polar diagrams so that the amount of light falling on the ceiling, walls, and floor might be evaluated. Preliminary experiments showed that the efficiency was independent of the total flux, so that it was not necessary to scale correctly the total flux, so long as the total flux emitted was known, and as a visual appraisal of the scheme was not attempted.

In all cases a single lamp was suspended from the middle of the ceiling in a model made to a scale of 1 : 10. The size of the model was variable and was capable of being moved in two directions at right angles along rails on a table forming the floor of the model. Through this table was inserted a photometer, and observations were made of the intensity of illumination at points 10 cm. apart in the model corresponding to points 1 metre apart in the full-scale room. The failure of the model to reproduce the variations from point to point is attributed to the dissimilarity between the light distributions of the full scale and model sources. However, a series of experiments was carried out investigating the factors which did influence the efficiency of the installation. These are hanging height of sources, the light distribution from the sources, the number of lamps and their distribution, reflection coefficients of ceiling, walls and floor, furniture, and size of room retaining all the ratios of its different constituents.

Hasenkamper (4) gives the following formula for the flux falling on a plane 1 metre above the floor:—

$$\phi_N = \phi\ (1 + 0.00017\ \gamma_B\ \gamma_W) + \phi_D\ \gamma_D\ (0.0012 + 0.000037\ \gamma_W) + \phi_W\ K_W$$

where ϕ_B, ϕ_D, ϕ_W are the flux which fall directly on the floor, ceiling, and walls respectively.

γ_B, γ_D and γ_W are the reflection factors of floor, ceiling, and walls respectively and k_W is a factor which he calls the "Wandnutzfaktor."

In a paper on photometry as related to illuminating engineering[5], W. F. Little describes the following approximate solution to a problem on factory-room illumination, using R.L.M. reflectors with bowl frosted lamps showing windows and machines. The R.L.M. reflectors were cut from 2 inch wooden blocks and automobile tail lamps used as light sources. Three different combinations of ceiling and walls were available. The model room was inverted in order that the photometer test plate might be inserted through the holes bored in the floor. In this way the illumination in the model-room was studied at a minimum of cost.

As it was not feasible to place window glass in the side walls, black paper was selected having the same reflection factor as the glass and attached to the walls, and a paper of somewhat higher reflec-

	Actual Room			Model			Difference	
	ϕ_n in Lm.	η in %	g	ϕ_n in Lm.	η in %	g	η in %	g in %
Bare Lamp ...	2035	56.2	$\frac{17.6}{82}=0.21$	58.0	58.0	$\frac{42}{220}=0.19$	−3.1	+10.5
Metal Reflector...	1800	64.0	$\frac{11}{137}=0.08$	53.5	62.5	$\frac{34}{240}=0.14$	+2.4	−43.0
Light Mainly Downwards	1605	70.0	$\frac{8.9}{115}=0.08$	51.0	68.0	$\frac{32}{225}=0.14$	+2.9	−43.0
Light Mainly Upwards	1830	62.1	$\frac{13.7}{102}=0.13$	33.1	61.0	$\frac{26}{122}=0.21$	+1.8	−38.0
Bare Lamp in Room with two large Windows...	1890	53.0	$\frac{17}{77}=0.22$	54.0	54.0	$\frac{47}{210}=0.22$	−1.9	±0.0

ϕ_n = total flux emitted. $\quad g = \frac{E\ min^m.}{E\ max^m.}$

η = efficiency in %.

tion factor, corresponding to the average for machines, was placed on the floor. The resultant illumination was a fair approximation of the illumination which was actually produced in the room corresponding to the model.

It is interesting to note ([6]) that, prior to the Ideal Home Exhibitions, Olympia, the proposed lighting effects are experimentally studied and planned by means of a large model, scale ½ in. to 1 ft., constructed and kept for this purpose. Other models were also made of proposed exhibition stands for the same purpose.

A recent contribution to the study of interior artificial lighting is that by Higbie and Bychinsky ([7]). They point out that in many cases consideration of the average illumination on the working plane by the "Flux of light" method, involving use of a "coefficient of utilisation" gives us no accurate idea of the illumination at any particular point.

Bychinsky ([8]) has designed an autographic apparatus for making lighting surveys in scaled models of buildings, but in this paper it has been described as applied to investigating systems using luminous panels in the side walls.

The general arrangement is illustrated in the figure. An adjustable angle-iron framework four feet square and two feet high can be made into a model room of any proportions within these limits, by means of removable plates of sheet iron arranged

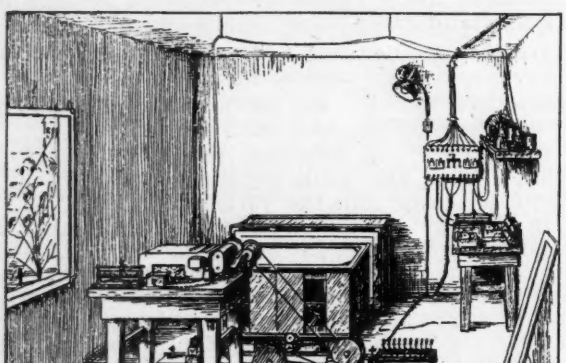


Fig. 2. Lay-out of Autographic Apparatus (Higbie and Bychinsky).

to permit the adjustment of size and position of openings in the side walls and ceiling for admission of light from the uniformly bright surface of "light boxes." One of these "light boxes" is shown sending light into the model room (which occupies the middle ground of the figure) through opening in the rear wall.

A photo-electric cell in a small rectangular housing is mounted on a track laid normal to the near and far walls. On the top side of this housing is a piece of depolished diffusing glass toward which the light-sensitive surface of the cell faces. The housing can be adjusted so that the diffusing glass is horizontal or vertical facing any one of the four side walls. By means of a suitable gearing to a motor, the photo-electric cell is caused to move along a line parallel to the far wall and 1.5 inches from it, then on reaching the side wall to move to another parallel line 3 inches farther from the far wall, and so on until all the working plane has been completely explored by as many as sixteen traverses. The near wall and ceiling are both capable of adjustment, thus changing the proportions of the room to correspond to wide ranges of "Room Index."

In order to make the current from the photo-electric cell actuate a recording device a specially designed amplifier shown on the left was designed. In it the lateral movement of a concentrated light beam was made proportional to the illumination on the photo-cell test plate. This beam fell on a strip of photographic paper, which, by suitable gearing, was given a longitudinal motion proportional to that of the photo-cell. The final result that appears when the paper has been developed is a curve whose ordinates, measured from a reference line, are proportional to the illumination on the test plate.

The calibration of this instrument was achieved by means of a photometer bar mounted at right angles to one of the light openings in the far wall. The photo-cell was mounted at various convenient distances along this bar and the light densities on its test plate measured by a Macbeth Illuminometer. Comparison of these values with the corresponding heights of the photographically recorded line established the foot-candle scale.

Both ends of each traverse of the room were denoted by marks at one edge of the record strip made by another element of the oscillograph, actuated by an electric current through contacts made between the photo-cell and stops at each end of its line of travel. The gearing was such as to make about 9 inches of record for each traverse of 4 feet and a complete survey of sixteen traverses required about five minutes and the photographic development another fifteen minutes.

Experiments were carried out varying height of ceiling, lower edge of luminous panels, reflection factor of side walls and ceiling and shape of room, and the influence of number and arrangement of panels was investigated.

A summary of results shows that when illumination is derived from luminous panels in the side walls of a room from 44 to 73 per cent. of the total area of the horizontal working plane receives less than average illumination, and the minimum illumination may range at least from 13 to 75 per cent. of the average illumination. Such being the case, the usual flux of light method of design, based on utilisation coefficients, is hardly permissible without important modification, because it regards only the average illumination.

More work is being carried out on this subject.

Photo-electric Measurements of Daylight Illumination by the Use of a Model Room ([9]).

A series of experiments have been carried out by Z. Yamauti and K. Hisano on the diffused illumination produced by inter-reflection by the interior surfaces of a room, the reflection factor of which is constant throughout, and the results compared with those of simple theoretical calculations. The dimensions of the model room were chosen to give 1-10th of the actual size. The walls, ceiling, and floor were constructed with wooden blocks of 10 cm. width and 2 cm. thickness, so that the size and position of the window and the size of the room could be altered in 10 cm. steps, the maximum sized model investigated measuring 100 cm. × 100 cm. × 70 cm. All the interior surfaces of the room were covered with white blotting paper, whose reflection factor was nearly constant at 80 per cent.

The light source consisted of a metal box containing nine 100 w., 95-volt gas-filled tungsten lamps. The box had a window covered with a piece of opal plate glass, and between the lamps and this plate was placed a piece of frosted plate glass. The interior surfaces of the metal box were painted with well-diffusing white paint. The brightness of the glass surface was practically uniform at about 0.163 c./cm.^{2}, and of nearly perfect diffusion.

A caesium gas-filled photo-electric cell of medium size with Wratten K_3 filter, mounted in a small case attached at a hole in the middle of a wooden plate measuring 200 cm. × 10 cm. × 2 cm., was used as photometer. On the other side of the hole in the wooden plate was attached a cylinder of 7.5 cm. in length, the end being covered with a piece of opal glass plate. The plate was designed to be analogous to a transmitting test plate at the standard working plane. With this equipment the galvanometer deflection was proportional to the illumination on the

test plate and the voltage on the photo-electric cell was constantly regulated so that 1 mm. deflection represented 1-1000th of the illumination of a point on the horizontal plane due to a hemispherical sky of brightness equal to that of the surface of the source box. This was obtained by adjusting the voltage on the cell so that a galvanometer deflection of 9.9 mm. was obtained when the cylinder plate was 50 cm. from the centre of a circular window of the light box of 10 cm. diameter.

When all the interior surfaces of the model room except the window were covered with velvet the direct illumination was obtained. When the walls were covered, however, with blotting paper the total illumination was obtained. The difference between these two sets gave the diffused illumination at the point under test.

The following conclusions were arrived at as a consequence of the experiments:—

(1) The daylight factor determined experimentally and obtained graphically or by the Higbie Leven's formula coincide.

(2) The diffused illumination is uniformly distributed all over the entire working plane.

(3) The diffused illumination is proportional to the size of the window.

(4) The diffused illumination is inversely proportional to the total area of the interior surface of the room.

The Efficiency of Light Wells ([10]).

In many buildings the lighting of the lower floors during the daytime is largely provided by internal light wells. When the building is high, unless the light well be unusually wide, only a small portion of the rooms facing the well on the lower floors can have any view of the sky, and the remainder of the light entering the rooms must, therefore, depend on light reflected from the walls of the light well. It follows that it is of great importance, in planning for the use of daylight in buildings of this kind, to know the amount of light received at various depths in a well of any given dimensions when the surface of the well has a given reflection factor.

The calculation of the intensity of illumination at any point on the surface of a light well due to a uniformly bright and diffusing surface at its open end is one of extreme difficulty and has been solved for a cylindrical well, but for other forms the calculation is still more difficult, and in most practical cases the light well in its simplest form assumes a rectangular cross section. It was, therefore, investigated by the use of scale models.

The first work on this subject was done by Dr. Clayton H. Sharp ([11]). He used scale models and an artificial sky and investigated two shapes of well, square, and rectangular with length equal to half the breadth, and his measurements extended to a depth equal to nine times the length of the well. Four matt internal coatings were used, having reflection factors respectively equal to 88.5, 86.7, 40 and 32 per cent. Measurements were also made with an enamel white coating.

The brightness of any point on the wall of the well is due to two factors: (a) direct light from the sky, and (b) light inter-reflected from other portions of the light well. The relative effects of these two factors will vary considerably with the depth of the point considered below the surface of the well. The variation of the value of the first factor can be derived mathematically from first principles for limited positions of the point considered and for standard shapes of the cross section of the well, but can also be obtained graphically by the Waldram or several other methods for all positions of the point and for all shapes of the cross section of the well. The values obtained by Dr. Sharp do not, however, agree with the calculated values; the difference must be attributed partly to the fact that the reflection factor of the matt black coating, which covered the walls of the well in this series of measurements, is not zero, especially in the case of large angles of incidence.

The results obtained agreed fairly well, as far as they could be compared, with those of H. F. Meacock and G. E. V. Lambert.

In the latter work an artificial sky was achieved by placing the model in a large whitened room 18 × 9 × 11 ft. illuminated by means of two large gas-filled lamps. For convenience in obtaining observations the model was fixed at right angles to and through the middle of one of the 18 ft. sides of the room so that the open end was vertical and approximately at the centre of the room. On the side of the model a detachable gangway G was fitted to provide

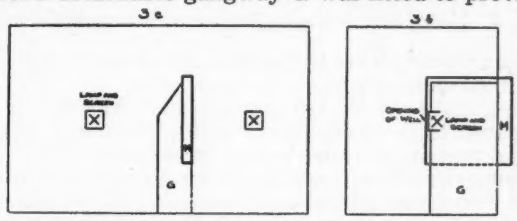


Fig. 3. Showing position of model well in room to achieve artificial sky.

a screen for the observer, and the large room was divided into two almost cubical compartments. The whole of the interior surface of the room and the surfaces of the gangway and of the model were whitened. A lamp was suspended at approximately the centre of each compartment and was in such a position and so screened that no direct light or screen could be seen from any point on the aperture or open end of the well. A series of measurements made over the whole of the surface of the room from which the well would receive its light showed that in no case did the brightness differ by more than 15 per cent. from the mean value, while the uniformity was much greater than this over the most important portion of the surface.

The work was intended to cover a series of rectangular light wells, and although there are three dimensions which may be varied, one of these was maintained fixed and the variations confined to the other two. The principle involved is that the amount of day-light illumination reaching any point in a building is the same, no matter what the absolute dimensions of the building may be so long as the proportions are not altered.

Measurements were made on all the models when coated with each of five different paints covering a wide range of reflection factors. Since the type of reflection is of extreme importance, especially as far as the amount of light received at the bottom of the well is concerned, to secure definiteness of results coatings having as nearly as possible perfect diffusing properties were used. The bottom of the well was in all cases covered with black velvet.

Measurements were confined to positions on the centre line of the wall forming the length of the well, since it was found that the illumination half-way between the centre line and the corner of the well was never more than 13.5 per cent. below that at a point on the same level, but in the centre line of the wall.

Description of Model Wells.

The construction of the models is shown in the diagrams, O is the opening of the model, L the length

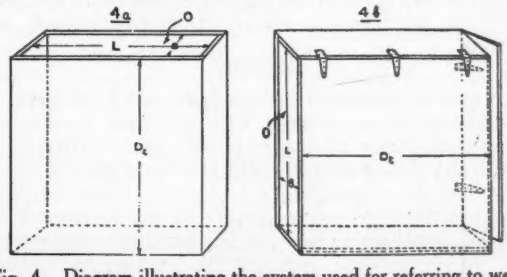


Fig. 4. Diagram illustrating the system used for referring to well dimensions.

and B the breadth of the opening and D' the depth of the model. The side nearest the observation gangway was hinged at the top and a door covered with

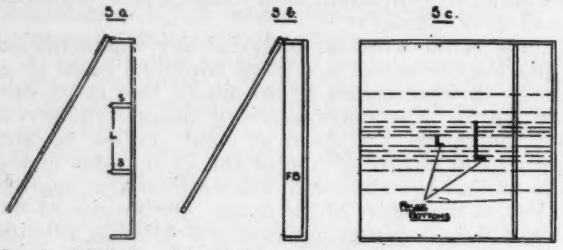


Fig. 5. Method used for altering the dimensions of the model well.

black velvet to form the bottom of the well hinged to the fixed side.

As L had to be varied two separate sides, SS, were prepared to fit inside the model. The depth of the model was made variable by a false bottom FB.

Throughout the investigation an illuminometer was used for making the measurements. To obtain the illumination at the opening of the well a small hole, just large enough to admit the nozzle of the instrument, was bored in the wall of the whitened room opposite the model. A test card was then suspended at various positions in the plane of the opening of the well. The measurements obtained showed a variation of not more than 2 per cent over the whole area of the opening of the largest model.

The points of observation were on the centre line of one wall of each model and the wall opposite the hinged side was selected for this purpose. Along the centre of the hinged side a channel was cut just wide

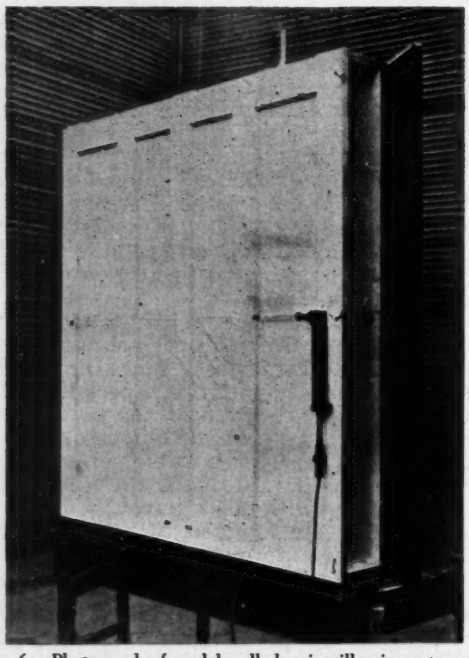


Fig. 6. Photograph of model well showing illuminometer and test card in position.

enough to admit the nozzle of the illuminometer and then slats introduced so that the side was enclosed except at the point where a measurement was required.

Results.

The results obtained were expressed both graphically and by means of empirical formulae for the particular conditions of the experimental points.

Daylight factor due to light received directly from sky:

$$R_0 = \frac{1}{\pi}\left\{\tan^{-1}\frac{L}{2D} - \frac{1}{\sqrt{1+\frac{B^2}{D^2}}}\tan^{-1}\frac{L}{2D\sqrt{1+\frac{B^2}{D^2}}}\right\}$$

where L = length of opening
B = breadth of well
and D = depth of observation point.

Reflected daylight factor:

$$R = (0.4541 \times 10^{-xd})\ \rho^m$$

where $x = 0.117 + 0.149/l$
ρ = reflection factor
and $m = 1.519 + 0.33d$.

$$l = \frac{L}{B} \text{ and } d = \frac{D}{B}$$

Tiles were made specially for use and were glued on to the existing models with slight modifications. The experiments were repeated with these models, the reflection factor of the tiles having been found to be 73.5 per cent. The results

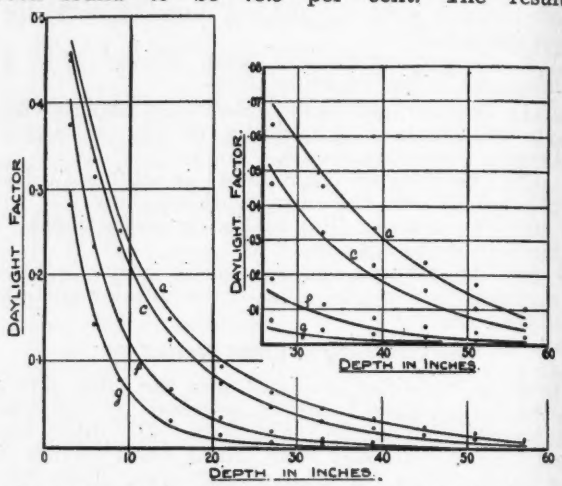


Fig. 7. Comparison of Results obtained with white glazed brick and with matt coating.

obtained were compared with those for the matt surface of reflection factor 80 per cent. In the graph the points indicate the results obtained from tiled models and the continuous lines those for the matt surfaced models. It will be seen that a glazed brick well is less bright than a matt coated well at the top, but brighter at the bottom. The differences are, however, quite small except at considerable depths.

An example is given showing the method by which the results obtained may be used to find the illumination at any point in a room lighted by means of a well of given dimensions, the walls of the well having a given reflection factor.

Although the surfaces of the model wells studied were all uniform, whereas in the case of an actual well there are numerous openings occupied by windows which may be regarded for all practical purposes as non-reflecting, provided these openings are not too irregularly distributed, the results may be applied to the practical case by making a suitable reduction in the reflection factor assumed for the walls of the well.

This work is of importance because the results have been actually compared with results from actual full-sized light wells ([12]). The measurements were carried out on wells in the new Government Building, White-

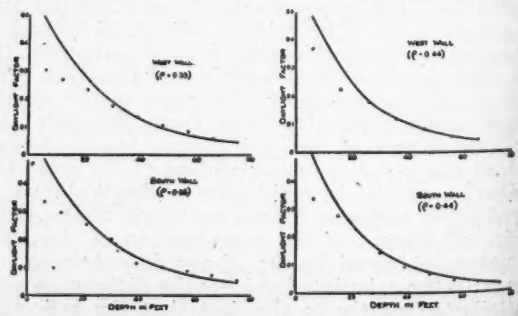


Fig. 8. Comparison of calculated daylight factor (full line) with results obtained from measurements (dots).

hall, and Thames House, Westminster. The agreement with the results derived from the empirical formulae is quite good considering the variability of sky brightness, irregularity of the upper edges of the well and uncertainty of the reflection factor to be assumed.

Natural Lighting of Picture Galleries ([13]).

At the request of H.M. Office of Works, which is responsible for the public galleries which house the national art collection, experiments were carried out by the National Physical Laboratory on a proposed form of roof lighting. The problem involved was that of securing adequate and suitable lighting in picture galleries without unpleasant reflection in the glass with which the pictures are protected. The considerations which chiefly affect the suitability of the lighting in a picture gallery are colour, screening of direct sunlight, and avoidance of reflections. The avoidance of direct sunlight may be achieved by having sunblinds or shutters which can be interposed, when necessary, to cut off the direct sunlight or by means of external screens.

Due to the fact that most of the pictures are protected with glass, any light object either on the opposite wall or in the centre of the gallery will be brilliantly reflected in the glass and the observer's view is disturbed by these superimposed images. This principle almost invariably makes it necessary to light a picture gallery from above. This gets rid of the reflections of the window, but those of the bright surfaces on the other wall, the spectators and other objects in the centre of the gallery, are less easily eliminated.

Consideration of the reflection factor of the glass and for bright objects which may occur in front of the object, led to the figure of 1/1.54 for the ratio of the intensity of illumination of the object to that of the picture, for the image of the object to be innocuous.

It has almost invariably been the custom in the past to build a picture gallery oblong in plan, and to exhibit pictures on each of the two long walls. Each of these walls must receive adequate light, so that in these circumstances it is impossible to fulfil the conditions for the avoidance of reflections. One method of getting rid of these reflections is to convert the double gallery into two one-sided galleries by the provision of dark-coloured featureless screens down the centre. This arrangement is, however, often regarded as open to objection on aesthetic grounds. In spite of this the reflections of spectators and objects in the centre of the gallery have still to be avoided. To get rid of this the use of a kind of central false ceiling known as the velum, or velarium, has been suggested; this, however, may be objected to on aesthetic grounds.

Where it is necessary to have a two-sided gallery, and where the roof may be modified, it is suggested that the design shown in the figure may be adopted. It has been investigated by means of scale models at the National Physical Laboratory. The model was constructed to a scale of one-third so as to represent two-thirds of the length of Gallery XVII. at the National Gallery, being 27 ft. long, 13 ft. wide, and 6 ft. high.

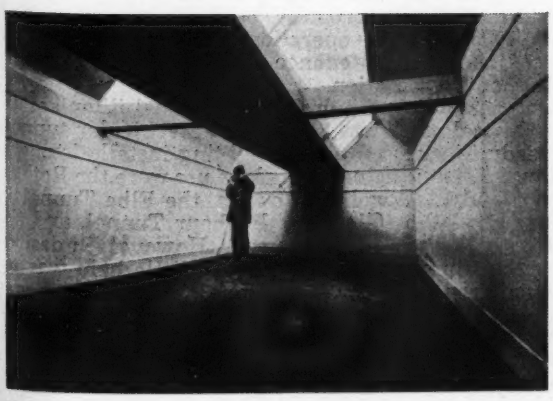


Fig. 9. Interior of Model Gallery.

The effect of variation of height of exterior screen to prevent access of direct sunlight and suggested values for height at given seasons of the year and the effect of interior decoration were investigated, and the important fact found that in a gallery of the form of the model the amount of light falling on any picture depends only slightly on the tone of the colour of the walls. The factors chiefly affected are the amount of light illuminating objects near the centre of the room and the reflections in the glazing of the wall on the opposite side of the room. It was also found that by darkening the roof and walls above the 14 ft. line, reflections were considerably reduced and in other cases completely eliminated. These experiments were carried out with the gallery running east and west. Owing to the necessity for preventing the access of direct sunlight the screen in the above case cannot be used for a gallery the length of which lies in the north and south direction. To investigate the possibilities of using the same section of roof with different screening arrangements the model was turned through 90° and the system of screens shown in figure erected. Six vertical screens across the roof of the gallery were used equally spaced along the length of the gallery, and it was found that a larger number of screens was necessary to shield the walls completely. Twenty narrower screens were next used, each of which could be tilted, with a large screen completely filling up the space between the ridges at the south end of the gallery. This system produced a satisfactory symmetrical distribution of illumination over the walls of the model gallery whilst the illumination of objects in the middle of the room was reduced, although not sufficient completely to satisfy the conditions set forward initially.

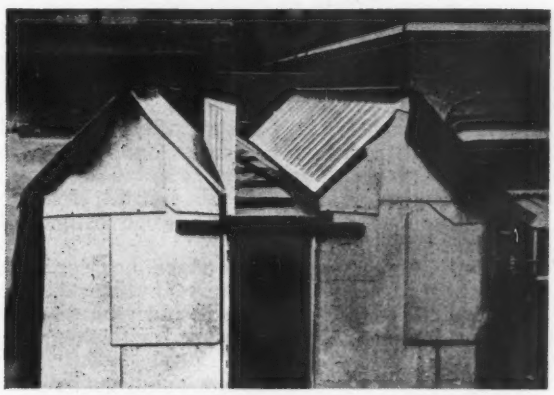


Fig. 10. Exterior of Model Gallery (East—West).

This form of roof construction, although eliminating reflections from spectators, does not avoid those of objects on the opposite wall. The only completely satisfactory solution is to abolish the double-sided gallery and to design a room where there is only one picture wall. Experiments were carried out at the National Physical Laboratory by means of models to a scale of 1-12th to determine the most suitable dimensions for combining adequate illumination of the picture wall with complete freedom from reflections. The model was constructed so that either wall with its own half of the roof could be adjusted in height relatively to the floor and the half containing the picture wall could be moved either towards or away from the other half. Observations were made by means of an illumination photometer sighted on a strip of white paper through suitably placed holes in the passage wall. The length of the gallery lay approximately N.W. and

S.E., and experiments were carried out to determine what lateral screens would be necessary to shield the picture wall from direct sunlight. It was found

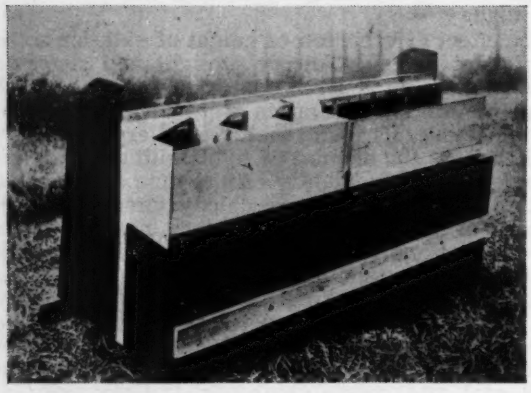


Fig. 11. Experimental Model of Gallery XIII.

that the necessity for such screens could be obviated, and a longitudinal screen was added with the following advantages:

(a) All reflection of sky in the glass of the pictures visible to an observer situated in the position of view was eliminated without tilting the pictures.

(b) The variation of daylight factor was made more gradual up the picture wall.

The gallery (Room No. XIII. in the new Duveen wing at the National Gallery, Millbank) was erected in general conformity with the design, and has proved in practice to give the results predicted from the measurements on the model.

Measurement of Insulation ([14]).

In problems relating to the incidence of sunshine upon buildings the use of scale models, with a lamp to represent the sun, affords many advantages. The Heliodon and the Pinhole camera developed by Messrs. Dufton and Beckett at the Building Research Station, and the Waldram Sunshine Gauge are suitable instruments for measuring or predetermining sunshine either in rooms or models, but the Heliodon is the more convenient instrument for investigations on models.

The model, which may consist of the exterior walls of a house, a window, a street, or anything in fact which it is desired to investigate, is placed in the correct orientation upon a board marked with the points

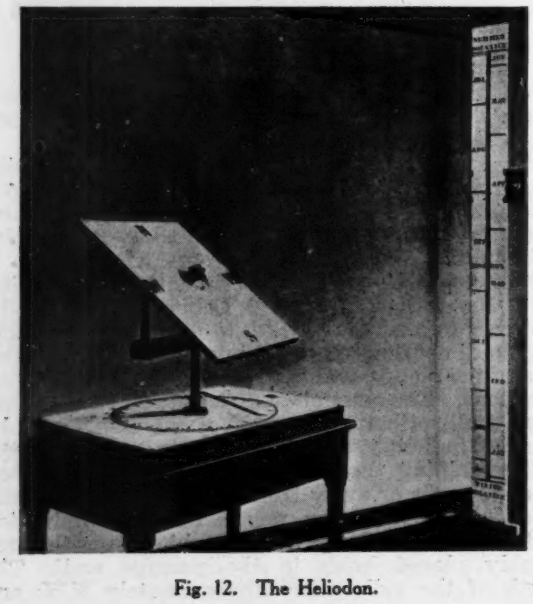


Fig. 12. The Heliodon.

of the compass, whose inclination to the vertical is accurately adjustable for any required latitude.

The course of a day can be imitated by rotation of the board about a vertical axis fixed in relation to a lamp representing the sun, the time corresponding to any position being indicated by a pointer upon a circular scale of solar time. Change of season is effected by sliding the lamp upon a vertical scale.

With this apparatus it is possible to reproduce exactly the incidence of sunshine upon a building for any given conditions, while daily periods of insolation can be obtained directly by rotating the board and noting the times at which the sun commences and ceases to shine upon various parts of the model.

Other attempts to utilise models were made in 1914 by L. B. Marks and J. E. Woodwell ([15]), who evolved two forms of apparatus. The first, shown upon a model, comprises a simple hemispherical wire framework, in which the sun paths for the solstices and equi-

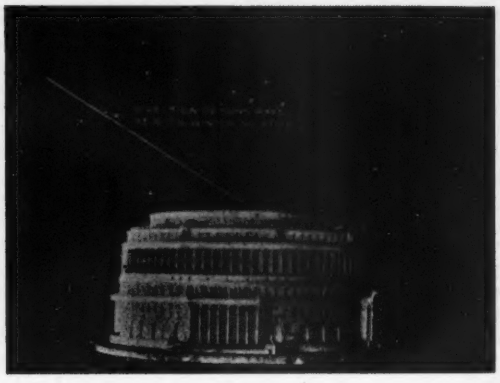


Fig. 13. Marks and Woodwell's Apparatus.

noxes are indicated and are marked by knots at hourly intervals. With the frame correctly oriented upon or near a model, it is possible to adjust the position of a lamp representing the sun for the required season and time of day. A similar apparatus was designed by W. H. Connell ([16]).

Exterior Artificial Lighting.

The Hudson River Vehicular Tunnel ([17]).

Twin tubes were driven under the Hudson River for vehicular connection between Manhattan and New Jersey. The tunnel was constructed for two lines of traffic in each direction, and the expected capacity was 23,000 vehicles per day in each direction. The external diameter of the tubes was 29½ ft., about the height of the average three storey house. The internal diameter of 25½ ft. provided a road passageway, the equivalent of many of our streets. In view of the density of surrounding traffic both in New York and Jersey Cities, it was necessary for the tunnel engineers to solve all their problems, keeping in mind particularly the handling of a maximum traffic at the greatest speed commensurate with safety. Successful operation, therefore, meant the provision and maintenance of adequate and carefully designed illumination.

In considering the problem of tunnel illumination, the logical start was to study the vehicular tunnels already in service and the lighting installations employed. The principal tunnels in use were the Rotherhithe and Blackwall in London, the Elbe Tunnel in Hamburg, the Glasgow Harbour Tunnel, and the Liberty Tunnels in Pittsburgh. However, in designing the illumination system very little help was received from studies of previous practice. This was due primarily to difference in traffic conditions, secondarily, to differences between the new tunnels and existing tunnels, bridges, and streets. Furthermore, the opinions and suggestions of various individuals were so widely at variance, that it was impossible to draw any sound conclusions. On the ques-

tion of intensity of illumination alone, proposals were received varying from 0.5 to 10 foot-candles. It was obviously necessary to strike a balance such that ample illumination would be provided and yet that installations and maintenance costs would not be out of line with the tunnel construction and operation as a whole. These considerations, together with the necessity for visualising the appearance of the tunnels and the actual driving conditions with different types and positioning of units, led to a model tunnel being constructed. A scale of one inch to the foot was chosen, and a length of 10 ft., corresponding to an actual tunnel length of 120 ft., was selected as fairly representative. In the actual tunnel the roadway was 20 ft. wide, and the height from floor to ceiling is 13½ ft. The dimensions were reproduced

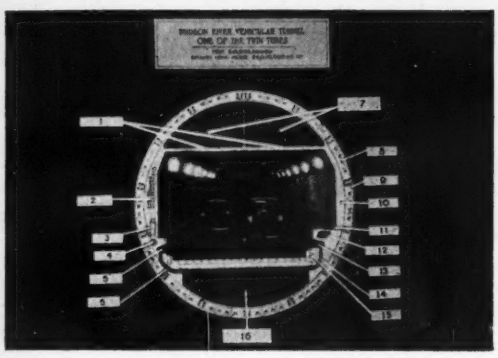


Fig. 14. Hudson River Tunnel Model.

to scale in the model, as also the three-foot pedestrian passage, complete with railing, the kerbs and the lighting units 20 ft. apart on both sides of the tunnel.

Various types of units had been proposed from time to time for lighting the new tunnels; all of those which held out any possibility of satisfactory service were made up to scale and tested. Since it was absolutely necessary that all glare be eliminated, two possible methods were available, an open deep bowl type of unit pointed down the tunnel in the direction of the traffic, and a comparatively shallow symmetrical unit provided with a diffusing cover. After the possibility of glare is eliminated the question of distribution of lignt and the presence or absence of shadows must be considered. It was decided that best results would be obtained with diffused light and uniform illumination, it being practicable to treat the problem in the same manner as a gymnasium, armory, or other large space devoted to a considerable movement of a large number of persons or objects. Tests were made in the model as to direction, angle of tilt, and type of unit in order to eliminate glare, production of shadows and "tunnel" appearance. The variation in available data as to a suitable intensity of illumination was so great that considerable study was given to the question. Miniature automobiles, constructed to the same scale as the model tunnel, were run through in different groupings, and the play of lights and shadows between and on the vehicles and curbs, given special attention. Because of the good diffusion of the light in the model, the shadows were soft, showing just sufficient contrast to give good discrimination. As the result of many tests, it was decided that 1.5 to 2.0 foot-candles, as measured without vehicles in the roadway, would give excellent driving conditions.

Considering the floor area of the model allotted to each miniature lamp, and the lumens of the lamp used, a coefficient of utilisation of roughly 0.30 was deduced, and the result checked, using the known efficiency and distribution of the units. Complete details of the unit are given in the article on the lighting of the tunnel and of tests using various glass covers, direction of pointing angle of tilt and position.

Colour Floodlighting of Buildings ([18]).

The scale model was applied by the Lighting Laboratory of the Commonwealth Edison Company for experiments in colour floodlighting. The model was taken from an existing building, being patterned after the Northwestern Mutual Building at Milwaukee, certain changes being made in the design.

The building was floodlit by a battery of floodlights 120 ft. away, comparable to floodlighting from buildings across the street, and with this method

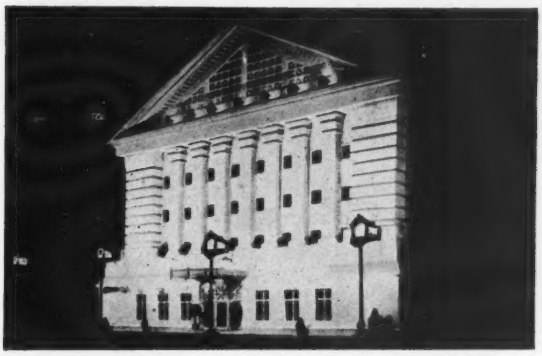


Fig. 15. Model constructed for experiments in colour floodlighting.

the building appeared flattened out. Under daylight the building had much more character than under floodlighting of this description.

Another method illustrated was that by means of standards at the kerb, say twenty feet away. There were three projectors per standard in addition to a local lamp lighting up the amber transparency. The scheme, however, is impossible where the public uses the space between the standards and the building. It is, however, feasible for buildings which are set back from any traffic space on a terrace or for buildings located in a park. The greatest objection again is the apparent flatness of the building.

A third method illustrated was the mounting of the projectors in pockets or crannies of the building itself. In many storied buildings, ordinances are issued in New York that after a certain height all buildings should be stepped back and this greatly assists the floodlighting of buildings by this method.

This form of lighting can never be made as uniform as the other systems. It will always be streaky because the angle is so grazing, but by correct application this streakiness can be made an asset rather than a disadvantage. A streak up each column accentuates the vertical motif of the building and increases its apparent height. The light sources are not so obvious as in other schemes.

The wattage per square foot required was adequately shown by the demonstration. The failure of many floodlighting attempts is often due to the failure of someone to have the courage of his convictions, i.e., timidity in the use of wattage. It must be remembered that in the course of a year the cost amounts to the price of several moderate newspaper advertisements.

The final demonstration was regarding the use of colour shadow lighting. The white light was concentrated on the pilasters, deep shadows being formed in between. Coloured light will exist in these shadows and will not appear where the white light reaches.

In the discussion of the use of the model, an interestering and well-known fact arose. In building the model, although it was taken from a building, certain changes were made in the design.

Buildings are designed with the idea that shadow is the principal thing to be gained when mouldings and other projections are used, such as cornices, etc.

The shadows that are brought out by these projecting parts of the building are designed on the basis of the light coming from above, from sunlight or moonlight. Now it is very difficult to arrange any kind of artificial exterior illumination of a building with light coming from below and get the effect that was intended. It is not impossible to design a building or a piece of sculpture, to be lighted from below, but it will not look right in daytime, and as one sees it more frequently in daytime than at night there is a serious difficulty.

Street Lighting Models.

Five street models are mentioned in the literature, but no indication is given, except in one case, of their use, except as pure demonstrations of the effects of

Fig. 16. The Osram-Lichthaus (Berlin) street model.

different lighting systems. The street model ([19]) in the Osram-Lichthaus, Berlin, previously mentioned, was executed on a scale of 1 : 25.

Lingenfelser ([20]) describes experiments carried out on a model street constructed on a scale 1 : 10. The materials forming the road surfaces had reflectivities ranging from black, through grey to nearly white. Spacings equivalent to 11 in., 14.5 in., and 18 in. were used, and intensities of 2.79, 1.96, and 1.48 lux were obtained with inequality ratios of 1 : 4.3, 1 : 6.9, and 1 : 11.4.

The E.L.M.A. street lighting model ([21]) represents a first-class city street of the Kingsway type lined with buildings representative of modern English architecture, and is built to a scale of $\frac{1}{2}$ in. to 1 ft. The

Fig. 17. The E.L.M.A. street model.

model is 5 ft. wide by 9 ft. long. The street is viewed from one end only, and at the other end is a plate glass mirror which gives the roadway the appearance of being twice as long. The mirror may be turned about one of its vertical edges to produce the effect of a bend in the road. Arrangement is made for demonstrating several lighting systems by means of a rise-and-fall mechanism.

A street-lighting model ([22]), quoted as being used to sell better installations loaned to the N.E.L.A. Convention, 1925, by the Edison Lamp Works, was built to a scale of $\frac{3}{8}$ in. to 1 ft. The buildings along the street were all representative of a typical American business street. It was possible by simple switching to give any desired spacing of standard with any desired size of lamp, there being 200 different combinations of street lighting in the model.

Window lighting was treated, as was sign lighting, by seven different types of signs. The model showed a type of traffic flasher as well as a traffic indicator. Flood lighting is shown where a splendid municipal building is bathed in white, red, amber, blue, and green.

Of greater interest is the model ([23]) ([27]) which has been built at the Nela Park Laboratories of the General Electric Company, Cleveland. This model, constructed for the purpose of aiding in the search for better "seeing" values, is built to a scale of 1 : 8, being 240 ft. long and representing a 2,000 ft. stretch of highway.

Although no test results are published the model is designed for comparing the relative seeing values of sodium vapour, high pressure mercury vapour, and tungsten filament lamps for a given expenditure, and for investigating the methods of application to best advantage.

The lighting units are adjustable in arrangements and distances from the kerb. Actual spacings from 125 to 500 ft. are available for one side mounting or staggered arrangement. Units can be put at any height up to 40 ft., full scale. The highway has an equivalent width of 30 ft. with 8 ft. green shoulders. Interchangeable pavement surfaces are provided, representing asphalt, concrete, or a wet block pavement.

Luminaire housings are so constructed that they may be shifted instantly from the sodium vapour source to the incandescent lamp or vice versa, and the amount of light and its distribution varied by a simple change in apertures. The light source rotors employed have four compartments with provision for the addition of high pressure mercury vapour lamps and one other source, when they are perfected, for horizontal mounting like the sodium vapour and tungsten sources. Provision has been made for raising and lowering various test obstacles and for moving transversely to the street such objects as dogs, cats, pedestrians, and cars. The model is housed in a light-proof structure and can be used for observations at any time of the day or night.

The use of models to illustrate road surface characteristics are mentioned by H. Warren and L. J. Davies ([24]) in a paper on the application of electric discharge lamps to road lighting.

Ground Lighting Equipment for Aviation.

Spacing of Boundary Lights ([25]).

As it is the function of boundary lights to indicate the shape of the useful area of the aerodrome the spacing of the lights is an important factor. A close spacing is advantageous from the point of view of clarity, but is high in installation and running costs. An endeavour was made to determine the maximum spacing of boundary lights which would indicate satisfactorily the perimeter of the landing ground.

For this investigation a model set of boundary lights was constructed by covering a sheet of opal glass with black paper in which small holes had been pierced at the position of the lights. The illumina-

tion of the opal glass was so arranged that the intensity from each light was equal to that from a lamp having an intensity in all directions of 60 candles, but reduced according to the square of the scale of the model. A visual inspection was then made at heights equivalent to 1,000-2,000 ft. with lights spaced 50 yards, 100 yards, 150 yards, and 200 yards apart.

A definite conclusion was formed from the inspection that with lamps of 60 candles the maximum spacing of the lights should be 100 yards for the shape of the aerodrome adequately to be described.

CONCLUSION.

In conclusion we can see that within limits models have been applied to both artificial and daylight lighting of interiors and exteriors. Although both specific and general problems have been attacked and solutions applied in some considerable measure, it is disappointing to find that no results are to be found of such application in the case of street lighting, since this problem is becoming more and more important as traffic conditions become more and more congested. It is to be hoped that this will be remedied to some extent by the model recently constructed by the General Electric Company of America. It is only fair to state in this connection that experiments are being carried out on actual roads, but the adaptability of a model must offer considerable attractions for this type of work.

In the case of the artificial lighting of interiors the inability to reproduce correctly the sources to scale has limited the application to that only of the investigation of the various factors affecting efficiency of installation. The speed of determination of results of the Higbie Bychinsky method shows that the model method of obtaining information regarding design of lighting systems is by far the best when sources of uniform brightness are used which can be produced accurately to scale.

The use of scale models for predetermining illumination, rather than for education in illumination principles, has been outlined. In the latter case it should be pointed out that there should be strict adherence to scale or the models will not give the impression of being real but only of exhibition cases.

I wish to express my thanks for the kind permission to reproduce the diagrams included in the text, in particular to the Controller of H.M. Stationery Office for Figs. 3, 4, 5, 6, 7, and 8 from Ill. Research Tech. Paper, No. 6, 1930, and Figs. 9, 10, and 11, from Ill. Research Tech. Paper, No. 11, 1930, and to the Building Research Station (D.S.I.R.) for Figs. 12 and 13. My thanks are also due to Mr. J. S. Dow, who has placed at my disposal the relevant journals and to Mr. J. Croney for the production of lantern slides and copies of diagrams.

APPENDIX.

Relation of Lighting of Model to Original [26].

We will suppose the original to consist of an object formed by matt surface and lit by several sources. We will show that if the ratio of the linear dimensions of the original to those of the object is λ and the ratio of the intensities of the sources is λ^2, the intensities of illumination will be the same at corresponding points of original and model. We assume there are no polished surfaces, no refracting surfaces, and no semi-transparent media. We neglect all diffraction phenomena. In those cases where the source is not a point source it must be remembered in applications that it is the light emitted by *corresponding* sources in original and model and not *equal* sources that must bear the ratio λ^2, e.g., with a line source a length λ S of lighting corresponds to S in model.

We will prove that if the sources in original all have intensities bearing the ratio θ to the corresponding source in the model, then the intensity of illumination at any point of any surface of the original bears the ratio θ/λ^2 to the corresponding illumination in the model.

Suppose it were not so. Then there is at least one point and one value of θ so that the intensity E in the original and the intensity E′ in the model satisfy

$$Y = E/E^1 \neq t \quad \text{where } t = \theta/\lambda^2.$$

Let a be the upper and b the lower bound of Y for all points where $Y \neq t$ (i.e. there are no points for which $Y < b$ or $Y > a$, but given any $\varepsilon > 0$ a point can be found so that $Y < b + \varepsilon$, and one so that $Y > \varepsilon$). $a - b$ clearly exists, and we will assume the existence of a (the proof can easily be modified in the case when a does not exist).

Then either

$$a = b \neq t$$

in which case either

$$a > t \quad \text{or } b < t,$$

or else

$$a > b$$

in which case

if $a = t$ $\quad b \neq t$ $\quad$ i.e., $b < t$

if $a < t$ $\quad b < a < t$

if $a > t$ either $a > b > t$ or $a > t > b$

in any case either $a > t$ or $b < t$.

Take the case $a > t$.

Let $E = E_S + E_R$ and $E' = E'_S + E'_R$ where the suffix s denotes that the illumination is direct from the sources and R that the illumination is received after reflection from the matt surfaces.

If dE_S be an element of illumination and dE'_S that corresponding we have

$$\frac{dE_S}{dE'_S} = \frac{\Theta}{\lambda^2} = t \quad \therefore \quad \frac{E_S}{E'_S} = t.$$

Then if P be a point for which $E/E' > a - \varepsilon$ we have

$$E_S + E_R > (a - \varepsilon)(E'_S + E'_R)$$

$$E_R > a(E'_S + E'_R) - \varepsilon(E'_S + E'_R) - E_S$$

i.e. $E_R > (a - t)E'_S + aE'_R - \varepsilon(E'_S + E'_R)$ since $E_S/E'_S = t$.

Now $a - t > 0$ and $E'_S > 0$ therefore we can choose ε so that $\varepsilon(E'_S + E'_R) < (a - t)E'_S$ i.e. $0 < \varepsilon < (a-t)E'_S / (E'_S + E'_R)$ and then

$$E_R > aE'_R \quad \text{i.e.} \quad E_R/E'_R > a$$

Now let light fall at P from some element of area $d\sigma$ of surface elsewhere and illumination e. This contributes $ked\sigma$ to E where k depends on the point where $d\sigma$ is, and on the location of P.

Therefore $E_R = \int ke \, d\sigma$ and $E'_R = \int k'e' \, d\sigma'$

$$= \lambda^2 \int ke' \, d\sigma'$$

$$= \int ke' \, d\sigma$$

$$\frac{E_R}{E'_R} = \frac{\int ke \, d\sigma}{\int ke' \, d\sigma} > a$$

$\therefore E/E' > a$ for some element, which is contrary to hypothesis. Our statement is thus proved for $a > t$ and can similarly be proved for $b < t$. The original statement follows on putting $\theta = \lambda^2$.

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DISCUSSION

of Papers* by P. D. Oakley, R. R. Holmes, H. S. Barlow and H. Lingard, read before The Illuminating Engineering Society on April 9th, 1935.

Mr. H. BUCKLEY expressed his great appreciation of the privilege of opening the discussion on the four very interesting papers which had been presented to the Society. Dealing with Mr. Oakley's paper, he congratulated the author on the efficient and careful manner he had established his visual photometric scale for the discharge lamps and his subsequent transference of the results to the photo-electric photometric scale. In connection with the use of the 2 deg. field in the visual work, he asked the author if he had determined the difference which would have resulted from the use of the full-sized Lummer-Brodhun field. At the National Physical Laboratory they had found that, with the larger field, the results obtained when a colour match filter was used on the comparison lamp side were 8 per cent. lower for the unmodified mercury vapour lamp and about 3 per cent. yower for the colour modified lamp. These field size effects were indicative that from the energy point of view the mercury light, particularly, and the unmodified light, was redder than the colour matching light transmitted by the filter. This supported Mr. Oakley's deduction from the slope of the curves showing the results plotted against the Y/B ratios of the observers. He himself had not obtained such a slope, as the spread of the results with twelve observers covered a range of nearly 10 per cent., and no observer with a Y/B ratio as low as 0.78 had been available whose results might have a very considerable effect on the slope of the curve. He found that the results were approximately independent of the Y/B ratio, which did not correlate as well with the results on mercury light as it did for continuous sources.

Continuing, Mr. Buckley pointed out that about 98 per cent. of the light from the unmodified lamps consisted of radiations of wave length 0.5461 μ and 0.5780 μ, whereas the centre of gravity of the luminosity curve of the colour matching light was about 0.55 μ. This, again, supported the suggestion that from the energy point of view the mercury light was the redder. He agreed with Mr. Oakley that the spread of the observers was less with the colour modified lamps. He also agreed with Mr. Oakley that the effect of the absorption of the sphere paint was small even for very considerable selectivity, and he had obtained similar results by combining with the sphere window an artificial selectivity produced by means of Wratten photometric filters 78c and 86c.

In connection with Mr. Barlow's paper, Mr. Buckley stated that he would like to explain that, in spite of the fact that a panel of the Technical Committee of the Society was mentioned at the head of the paper, the whole credit was due to Mr. Barlow himself. He himself was chairman of the panel which had been asked to report on the possibilities of the use of models in connection with illumination problems, and at an early meeting it had been found that a certain amount of work on the subject had been done and had shown the value of models. The panel had, therefore, asked Mr. Barlow to write a paper describing what had been done. It was with considerable surprise, therefore, that the panel had found that Mr. Barlow had discovered so much useful and interesting material to bring to the notice of the Society. The instances given by Mr. Barlow had shown very clearly that models could be of very considerable qualitative and quantitative help to illuminating engineers, and he was very glad that the Society had been able to call attention to their possibilities; he hoped they would find more extended application in the future.

Mr. A. CUNNINGTON said he supported Mr. Holmes's proposals because he felt that what had been suggested was a rough and ready presentation of illumination measurements which should be useful. Personally he had tried to explain to the non-technical person the ordinary iso-lux diagram, and he felt that this new sort of shaded diagram would have its uses. Perhaps, however, it would be better to have solid blobs instead of circles, and they could be coloured black or grey, and in that way there would be a toning off in shade from the large to the small ones.

Referring to Mr. Lingard's paper, Mr. Cunnington said he was delighted to see in black and white a record of some of the difficulties that illuminating engineers were up against when dealing with modern architectural lighting. Indeed, he would like to see the five points set out by Mr. Lingard printed in red and gold and sent out with a polite letter to architects. That might have the effect of ensuring that they would pay more attention to maintenance points in the future. Personally, he had suffered very much in the past from being confronted with a complete and finished scheme of decoration and then being told to get on with the lighting. If these points connected with maintenance were considered at an early stage of drawing up schemes, the final results from the illuminating engineering point of view would be very much better.

Commenting on the special nature of the meeting, Mr. Cunnington said that as chairman of the Papers Committee, he was pleased with the success of it. There had been a considerable amount of diffidence on the part of the committee in daring to recommend

* The papers by Mr. P. D. Oakley and Mr. R. R. Holmes appeared in our last (June) issue (pp. 181-188).

the council to have four papers on one evening, but the result, he thought, had been extremely satisfactory.

Lieut.-Commander J. G. DAMANT, commenting on the proposals of Mr. Holmes, remarked that although the author had been somewhat severely criticised from the scientific point of view, he was to be congratulated upon having looked at this matter from the point of view of the customer rather than the expert. Whatever the merits or demerits of what had been proposed, the fact that people were thinking a little of how to present these things to the lay mind was an excellent thing, especially from the sales aspect. There seemed to him to be very grave danger in Mr. Wilson's idea of shading, because the ordinary borough surveyor, looking at such a diagram, might be led to think that it was a badly lit street with black patches between the posts, whereas it might be excellent lighting. He therefore emphasised that the sales point of view should be kept in mind, because he felt that contour lines showing very small differences of illumination which were quite undetectable by the human eye, and therefore unimportant, were of no value to the customer either from the scientific or any other point of view. Iso-lux curves were very complicated, and something simpler, whatever it might be, was a very good idea indeed.

Lieut.-Col. K. EDGCUMBE expressed the view that the paper by Mr. Oakley was a particularly timely one, since reasonably accurate photometric measurements were essential and, on the other hand, the users of electric discharge lamps could not be expected to keep a staff of trained observers, each appropriately labelled with his respective Y/B ratio. Some method such as that outlined by the author would prove invaluable.

Referring to Table VII. of the paper, he inquired whether a filter had been used over the photo-electric cell or not. At the top of the paragraph it was stated that no filter was used, and, in that case, did it mean that the difference of, roughly, 8 per cent. for the plain mercury vapour lamp represented the difference between the light of the tungsten lamp and the mercury vapour lamp falling upon the cell with no filter? If so, this seemed to him to be an exceptionally small difference, because he would have expected something like 20 per cent.

The author had mentioned the use of a wattmeter. Did that mean that the current and voltage were out of phase on the lamps themselves so that an ammeter and a voltmeter could not be used to measure the power input, or was it merely that a choking coil was used in series?

Finally, Colonel Edgcumbe inquired whether selenium rectifier pattern cells were used, and expressing interest in the reference made, towards the end of the paper, to a filter which would correct for a very wide range of colour difference, he hoped that the author would tell them more about it in due course.

Dr. S. ENGLISH said he was sorry to join those who were not enamoured of Mr. Holmes's diagram which, he said, was for the benefit of employers, contractors, and customers. If an architect could not read a contour diagram, he was not much of an architect. An employer ought to be able to read one, but as to the customer, the position admittedly was not quite so certain. In considering Mr. Holmes's scheme, it should be remembered how easy it was to deceive the eye. The juxtaposition of circles varying in size was liable to deceive as to the relative size and, looking at the diagram displayed in the proof, he was not at all sure that his own eye had not played him a trick in that respect. If something simpler than a contour diagram was necessary, it seemed to him that a series of five simple curves might be drawn straight across the diagram, the height of the curve above the points selected being proportional to the illumination. This would give five simple sinuous curves that even the customer could understand.

Mr. W. J. JONES said he also felt that the iso-lux diagram gives a truer picture of the situation. At the same time, to the lay mind the idea of circles gave a representative idea of the distribution of light. One of the main difficulties of the method, however, was that it was purely a representation and could not be applied to any calculations. It did not enable one, for instance, to obtain the co-efficient of utilization or an estimate of the general efficiency of the system.

Passing to the paper by Mr. Barlow concerning models, Mr. Jones said that the paper demonstrated how extremely valuable and useful models could be in studying the efficiency of the distribution of light. At the same time, he asked Mr. Barlow's opinion on an entirely different phase of the subject, viz., the effectiveness of the lighting. In this he was thinking of such problems as glare. There was only a small amount of light entering the eye, and the general field brightness might be the same, but the total flux reaching the eye was very much less, and a false impression might be given. From this point of view the use of models to give a qualitative idea of the lighting might not be so valuable.

As regards the cost of models, it had been found that the cost of lighting fitting for these models might be many times the cost of the actual fittings used in practice, and that seemed to be one of the penalties of trying to carry out work of this kind on a small scale.

Commenting on the paper by Mr. Lingard, Mr. Jones said there was a practical point in connection with laylights. If daylight came in there must be some diminution in the efficiency, and figures showed that from the electric lighting point of view the running cost might be anything from 50 to 100 per cent. greater than if the laylight was totally enclosed.

Finally, Mr. Jones congratulated the Society on having had this symposium of papers which were extraordinarily valuable, and he hoped the idea would be repeated in the future.

Dr. J. W. T. WALSH, commenting on the paper by Mr. Holmes, said he would like to give a gentle warning as to the uses to which this method might be put. There were considerable dangers in its uses if the illumination was varying at all rapidly, and, as a matter of fact, that had been brought out by Mr. Holmes's example which had been demonstrated. The maximum circle was very considerably larger than the next highest circle, whereas the actual distribution was approximately symmetrical, and this seemed to illustrate that the principal application of this method was where the illumination was not varying very rapidly. In that case the method might be extremely useful, but for general use he personally felt conservative enough to prefer the isophot diagram, even if its preparation did involve a good deal more work.

Mr. G. H. WILSON, speaking on Mr. Holmes's paper, remarked that, although the method of portrayal used was clever, he did not think it justifiable. The contour method, whatever its defects, would not give an incorrect impression, whereas the distorted snooker table effect given by the author's method might be quite misleading. Mr. Wilson agreed that contours probably gave difficulty, and he thought that if some standard method of shading between contours could be adopted, it should help to make the contour diagram clear. As a matter of fact, he had tried to get out a schedule of shading before the meeting, but had found it very difficult, but, with a

little more time, he might be able to do so. It might be done after the conventional manner of drawing maps or electric circuits.

Assuming for the moment that a case could be made out for the circle-lux diagram, Mr. Wilson thought an important point arose. This was the question of the scale used for drawing the circles—whether their area should be in proportion to the illumination. At first sight, it would appear that a linear scale should be used, for when an illumination is doubled, there is twice the light flux falling on the surface in unit time. But when covering a large range of illumination values, e.g., sunlight to moonlight, the linear range represented diagrammatically was from the height of Mount Everest to that of a worm cast. (Mr. Wilson then showed a slide representing various illumination values as heights in this way.) Although Mr. Wilson considered a linear representation the best for demonstrating illumination values as heights, there seemed to be something in favour of adopting a square law for the relation where circles were used, as in the case of Mr. Holmes's diagram.

In order to examine this, Mr. Wilson had redrawn Mr. Holmes's diagram, using circles whose diameter was proportional to the illumination (Diagram A) and diagrammatic spheres whose volume was proportional to the illumination (Diagram B). Remembering that the ratio of the highest illumination to the lowest in Mr. Holmes's figure was about ten to one, Mr. Wilson had formed the opinion that the appearance of the largest and the smallest circles in his (Mr. Wilson's) Diagram A conveyed the impression of a ratio greater than ten to one. In regard to the spheres, these certainly conveyed the impression of a ratio far less than the true value. Mr. Wilson concluded, therefore, that if a circle-lux diagram were ever used, the portrayal of the illumination by circles whose area is proportional to the illumination, as Mr. Holmes had done, was the best method.

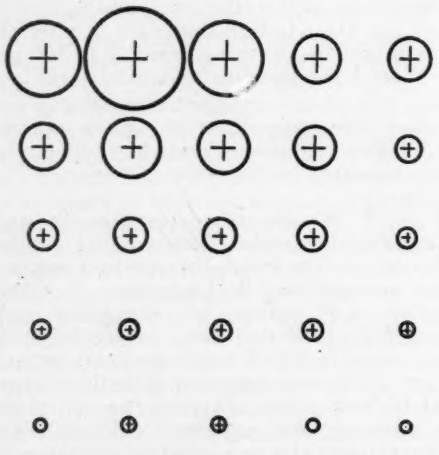


Diagram A.

In regard to Mr. Oakley's paper, he quarrelled with the first sentence of it, because it did not give a correct impression of the relative requirements of a modern works and a research laboratory. The paper did not define what the works' point of view was, but he imagined that simplicity was one very important requirement, and that lack of accuracy was a thing which could be tolerated. Personally, he did not think there was very much pure research work in illumination to-day. It was nearly all applied research, and we should not under-estimate the accuracy required from photometric apparatus used in a modern works. Therefore, in that connection he suggested that Mr. Oakley had been a little biased in the wrong direction. As a matter of fact, he knew of one works which was using much more complicated photometric photometers than those described by Mr. Oakley with very great success, and this apparatus gave a repetitional accuracy of something under 1 per cent., and he knew that that accuracy had been very well worth while.

Speaking with regard to the constancy of the output from the rectifier cell, Mr. Wilson said it was known that there was a variation of the current from the cell with time, but he would like to know the sort of precautions that had to be adopted when using the photometer to allow the cell to settle down so that the reading was reliable.

He observed that Mr. Barlow's paper suggested that the enhanced stereoscopic effects which were obtained with models should be taken into consideration when models were applied to street lighting. Although the scale was reduced the eye distance remained the same, and therefore it was possible that one could see more easily than in a full-size street. That should be taken into account when conducting visibility tests with a model. Mr. J. M. Waldram once made a little stereoscopic viewer which reduced the eye distance down in proportion to the scale of the model. Unfortunately, however, it had a very restricted field, and one could only look rather far ahead in the street. Therefore, it would probably not be of much value in model work.

With regard to Mr. Lingard's paper, Mr. Wilson asked for particulars of the opal glass used in the experiments in regard to transmission, absorption, and reflection. It was not sufficient to refer to a flashed opal glass, and if these details were given it would make the work described in the paper very much more valuable.

Mr. W. J. G. Davey showed two diagrams which are used in the Parkinson Lighting Research Bureau for depicting the distribution of street illumination, one of which was line shaded and the other coloured in different shades to represent different degrees of

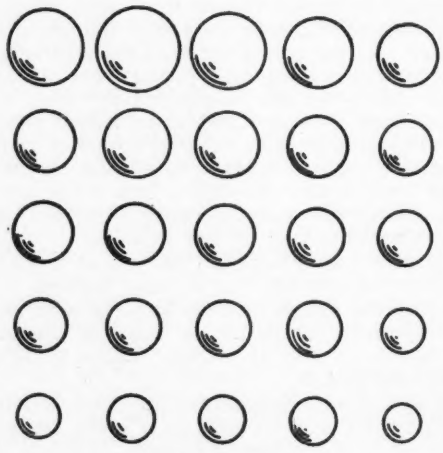


Diagram B.

illumination. He suggested that both are more satisfactory as giving a proper pictorial representation of the distribution of illumination than the circle diagrams given by Mr. Holmes.

Mr. C. A. Morton said that he had read Mr. Holmes's paper with interest, but did not think that the suggestion made had any advantage. The general contour method at present in use in illuminating engineering was an excellent method. Brigadier Winterbotham, until this year Director-General of Ordnance Survey, had expressed the view, in a recent broadcast talk, that everyone knew what a contour was. Such diagrams, familiar as isobars in weather forecasts in the daily Press, were of everyday occurrence. He did not think it could be claimed

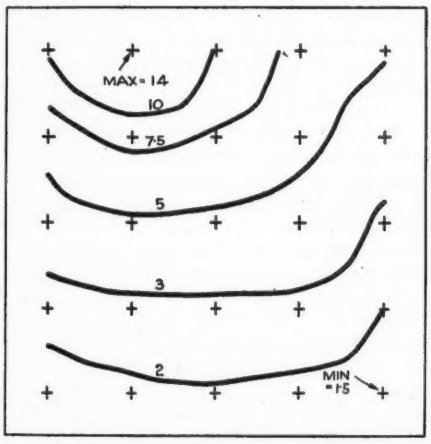
nowadays that a contour diagram was not easily understood, even by a layman.

As regards the use of contour lines in illuminating engineering, he would, however, suggest that no more lines should be used than those absolutely necessary, otherwise the diagram became irritating and confusing.

As an example, the contour lines in Fig. 1 would be less confusing with a little judicious pruning. The 12 ft. candle contour could be omitted with advantage. The contours for 6, 7, and 8 ft. candles could be replaced by one at 7.5 ft. candles. Both the 4 ft. candle and the 2.5 ft. candle contours were also unnecessary. Contours at equal steps of illumination should not be shown but, instead, contours at fewer intervals should be used. As the 2.5 ft. candle contour was equidistant from the 2 and 3 ft. candles contours, there was no need to portray it. The most satisfactory diagram contained an absolute minimum number of essential contours, situated, so far as possible, at equal distances apart.

The number and frequency of the photometric readings required for the preparation of a diagram was a matter of experience. Inspection of Fig. 1 made it fairly evident that it represented an industrial fitting, or, at any rate, some form for interior lighting. This being so, the eighty-one readings mentioned was an unnecessarily large number. Readings at 1 ft. squares as shown in Fig. 2 would be ample for the purpose of drawing a contour diagram, which would be practically identical with Fig. 1, but with only five contours.

In illustration of this point, he presented the following diagram, constructed solely from the data of the twenty-five values given in Fig. 2, and without



reference to Fig. 1. There were just the five contours mentioned, with points denoting the location of maximum and minimum values. The twenty-five points, each one foot apart in a square formation, gave data over an area four feet square. The eighty-one figure points in Fig. 1 in a similar formation, but six inches apart, also bound the same area. There was no evidence for the contours shown in the marginal addition, which he (Mr. Morton) had shown blank. It would thus be seen, referring to Fig. 1, that the contour diagrams were practically identical, and the five-contour diagram was much less confusing and more convenient.

It was not clear why the author had adopted only twenty-five readings for Fig. 2 and eighty-one readings for the iso-lux diagram. No doubt he was anxious to reduce the time necessary to a minimum, and probably also had in mind the appearance of the 25-circle diagram, which was certainly not unattractive. It did seem misleading, however, to infer that eighty-one readings were necessary for the contour diagram, and the contention that this (the author's) method of portrayal led to a saving of time did not seem justified.

With regard to the circles themselves, it seemed unnecessarily irritating to have to convert every reading to its equivalent circle, a slide-rule operation being thus necessary for every reading. A further drawback to the method was that it did not lend itself to interpolation so readily as the standard contour diagram.

If a contour diagram was to be avoided, it would seem preferable to tabulate on a plan, at the correct positions, the illumination values obtained there. If this simple plot were carried out, say, on squared paper, the method of flux summation, as mentioned by the author, was practically automatic.

Mr. H. R. RUFF (communicated): After reviewing this paper I should first like to congratulate Mr. Oakley on his paper and upon the practical information contained therein. I should like to confirm that we have found that selected photo-electric cells of the selenium-iron rectifier, or, as they are sometimes known, contact or photo-voltaic type, are satisfactory for commercial measurements of the luminous efficiencies of high pressure mercury electric discharge lamps.

One point which is of the utmost importance to users of such devices is the constancy of the calibration. Our experience with regard to this has been that there is a very considerable difference between different cells of the same type. We have also found that the use of an optical screen made of glass of the heat absorbing type, of a thickness of approximately 3 mm., which has the effect of reducing the ultra-violet and infra-red radiation present, often assists the constancy. In general, we have found that with cells of this type there is a tendency for a change to occur during the initial period of running. With some cells this change apparently is almost completed within 15 minutes, but with others change occurs for much longer periods. With selected cells, screened as stated, we have, however, been able to obtain a constancy such that the calibration of the complete equipment is maintained within 1 per cent. over a complete day's photometry with a single daily calibration. With an integrator and photo-electric measuring device in continuous use over a month we have also found that a change of the order of 10 per cent. may occur during a month's operation, and this change can, of course, easily be eliminated by the daily calibration.

The information given by Mr. Oakley of the screening of his cells to enable high pressure mercury, plus cadium, plus zinc lamps, to be photometered is most interesting, and from the results obtained the use of filter No. 86 appears to be most satisfactory. Our experience in connection with the comparison of different colours of light photo-electrically has been that careful check tests must be taken over prolonged intervals with the different colours of light being compared, and also with the particular photo-electric device being employed. There is often a considerable difference in the sensitivity of different photo-electric devices of the same type to different colours of light; moreover, the cells may change not only in their overall sensitivity to any given type of light, but also with regard to their relative response to light of different colours.

Mr. P. D. OAKLEY stated, in reply to Mr. Buckley's question about the difference between large and small field measurements, that it had been found that large field results were 5 per cent. lower in the case of unmodified lamps and 3 per cent. lower for colour modified lamps than the 2° field measurements. These differences corresponded with Mr. Buckley's figures of 8 per cent. and 3 per cent respectively.

Colonel Edgcumbe's difficulty with regard to table VII. was due to the fact that while no intentionally selective filter was used over the cell, the X 10 stop consists of a so-called neutral filter which did in fact have selective properties and alter the response as between Tungsten and Mercury light—on the X 1

range, that is the bare cell, the difference between Mercury and Tungsten is about 18 per cent., the mercury results being low by that amount.

A wattmeter was used to facilitate rapid setting to the rated wattage of the lamp. It would be possible, though rather inconvenient, to use the volt and ampere readings of the lamp, provided these were corrected for the lamp power factor, which is due to wave distortion and is very close to 0.9 for the lamps in question.

The cell was of the selenium blocking layer (Sperrschicht) type and is stated by the maked to give a photo-electric current of the order of 3 X 10^{-8} amp/Lux/Cm^2 illuminated cell area.

In Mr. Wilson's criticism there seemed to be some confusion between precision and accuracy. The advantage of a photo-electric method from a works point of view was that it lent itself to precision, that is, good repeatibility. Accuracy depended on many factors besides precision of measurement, and the whole level of results obtained over an extended period might have to be reconsidered in the light of later knowledge. High pressure electric discharge lamps were relatively new, and much more accurate knowledge was to be expected in the future regarding the true measurement of their light output in terms of the international standard of candle power than was possible at the present stage.

The output of the cell was very constant over the period of measurement. No settling down was necessary, and repeat measurements of the sub-standards during the course of a day were found to be in close agreement with the original set-up, which was checked every morning. In general this confirmed the set-up for the previous day, but a marked change in room temperature caused an error of the order of 1 — 2 per cent. and necessitated a small re-adjustment of the iris diaphragm.

Mr. R. R. Holmes, in reply, said that it might interest Mr. Cunnington to know that he had tried shading in the circles but without sufficient advantage to justify the extra time involved. Attention had been drawn to the limitations of the system by Dr. Walsh and to a possible optical illusion as to the relative size of the circles by Dr. English, and the author admitted that in the demonstration the variations in the illumination exceeded those normally experienced. In Figs. 10 and 11, however, which were prepared in the course of work for which the system was devised, neither of these difficulties would seem to be apparent.

Mr. Wilson, the author was relieved to find, was in agreement with him over the relation chosen between the size of the circles and the strength of the illumination, and for his various diagrams the author was most grateful.

Mr. Davey's diagrams were interesting but the time taken in preparing them would have prohibited their use in the circumstances for which the author's system had been designed.

Mr. Morton had given instructive details of his system of preparing Iso-Lux diagrams and, although still contending that the new system had certain advantages, the author was ready to admit that the times he had given for Figs. 5 and 8 might have been improved upon. The troublesome introduction of a slide-rule calculation in the new system was, perhaps, balanced by the fact that the actual readings appeared on the final diagram, whereas it was not always possible to tell, from an Iso-Lux diagram, at what intervals readings had been taken or to what extent interpolation had been employed.

In conclusion Mr. Holmes said that he would like to point out once more that the new system did show by means of a *visible dimension* the relative values of the illumination at points on the surface, and it was this "visible dimension" which he believed was more readily appreciated by the layman than the customary lines and figures.

Mr. H. Lingard, in reply to the discusssion of his paper, remarked that he was in the happy position of having a very light task. He thanked Mr. Cunnington for the encouraging remarks regarding the value of the contribution, and fully supported his suggestion of bringing such information to the notice of architects.

Mr. Wilson had raised a point regarding the characteristics of the flashed opal glass employed in the tests. In reply to this the author indicated that the flashed opal glass employed had a light transmission value of 66 per cent, according to figures supplied by the makers.

Mr. H. S. Barlow remarked that Mr. Jones and Mr. Wilson had drawn attention to points on which he would have liked the discussion to concentrate, that is, regarding a visual appraisal of the lighting system. The causes of glare might be principally due to two factors, namely, brightness and excessive candlepower, which concerned the light source itself, a third factor concerning its location in the field of view, and two others, contrast with background and time of exposure, depending on the conditions of use.

In the scale model the brightness of the full scale system were retained, hence this cause of glare and the question of contrast with background were eliminated, whilst the factor of time of exposure need not be considered. For the conditions that the total quantity of light falling upon the eye and the location of the sources in the field of view should be the same, the observer should assume a position in the scale model at the position of a scaled observer and view the model system with a miniature eye. This latter condition could not be satisfied, and this fact set a limit to the range of the visual appraisal of a lighting system by means of a model.

The question of cost of the models was an important one, it being difficult to obtain model sources at low costs. However, this need not be a deterrent where the problem being investigated was general. The point was brought out in the question of the lighting of the Hudson River Tunnel where only a small portion of the whole system was modelled. Again data might be compiled for general use in which the cost of the model would be comparatively small, as in the question of efficiencies of lighting systems in rooms of standard design. Whenever sources of uniform brightness were used it was easy to produce model sources. This was strikingly brought out by the fact that the majority of the problems investigated involved daylight and lighting due to luminous panels.

Reviews of Books

Architecture Luminose.

G. Canesi and A. Cassi, Ulrico Hoepli (L. Milan, 1935; pp. 162.)

This somewhat unusual production is almost entirely of an illustrative character. It contains 128 pictures of "architectural lighting" installations and eighty-eight views of novel types of lighting equipment excellently printed on art paper. The initial pictures deal largely with exhibition and spectacular lighting, some effective and original examples of fountain-illumination being shown. Interior lighting of theatres, cinemas, and places of entertainment is also fully treated (one observes how popular treatment with sweeping lines of light is becoming). The final section deals with fittings, chiefly combining diffusing glassware and shining metal, some of a decidedly ingenious and interesting type. Certainly a volume deserving inspection by illuminating engineers, architects, decorative artists, and fittings designers in this country.

National Physical Laboratory

Annual Record of Work

The programme prepared in connection with the usual annual visit to the National Physical Laboratory on June 25, together with the very comprehensive Report for the Year 1934 recently published, serve to show what a considerable amount of research on photometry and illumination is now being done.

It is of interest to mention that a new photometry building is now in course of construction. It is hoped to initiate the installation of equipment in 1935, and, no doubt, in the course of that year members of the Illuminating Engineering Society may have an opportunity of examining progress. In the meantime work on various aspects of photometry has been steadily proceeding. Routine commercial measurements and laboratory researches have been proceeding concurrently. Perhaps the most interesting investigations are those on photo-electric cells, which are being steadily improved and have been adapted to many different purposes. It is instructive to learn, for instance, that a corrected sensitivity to within ± 3 per cent. for light incident at angles up to 85° is possible, and that matt cellulose finishes have proved specially useful in improving the performance at high incidences.

Some of the researches on heterochromatic photometry and the testing of luminous discharge lamps have been recently presented in this journal. Much work has been done on other special topics; for instance, the measurement and continuous recording of daylight, and on problems suggested by the Department of Scientific and Industrial Research. Of these perhaps the most important from a practical standpoint are the reports dealing with crane lighting and with the relation of requisite illumination to size of detail viewed—the latter a problem on which an official report has been quite recently issued.. Among other special experiments we may note the devising of an automatic recorder of illumination at lighting-up times in offices.

There are many other bits of work that appeal strongly to the imagination, such as the use of the cathode ray oscillograph, to exhibit the nature of wireless "atmospherics," and the apparatus which, when in the neighbourhood of lost radium emits an urgent "clucking noise."

Lighting in Factories and Workshops

A fourth edition of the above "Welfare Pamphlet," issued by the Home Office, has recently appeared. Some additional illustrations are included (we also notice the inclusion, at the end, of advertisements by leading firms in the lighting industry), but it is a tribute to the excellence of the original booklet that so little alteration in the text has been found necessary. A summary of the salient points in the booklet also appears in Form 273.

The Association of Public Lighting Engineers

12th Annual Meeting and Conference London, September 9-12, 1935.

We have before us the provisional programme of the above Conference, for which exceptionally complete arrangements have been made by the President-Elect, Mr. A. M. Bell. The Association, after an interval of ten years, is returning to the city in which its first annual Conference was held. It is natural, therefore, that special efforts should be made to make this an exceptionally important and successful one. We understand that, even at this early date, registrations have been on an unprecedented scale, and we strongly advise those who wish to attend the Conference and have not yet sent in their names to do so without delay.

The programme provides for a reception at the Hotel Metropole (the headquarters) on the evening of the opening day (Monday, September 9), when guests will be welcomed by the President, supported by Sir Francis Goodenough and Sir William Ray.

(A new departure on the present occasion is the holding of the annual general meeting at 4 p.m. on the opening day so that the new President may be inducted before the formal opening of proceedings.)

The Conference will be formally opened at 10 a.m. on the following day (Tuesday, September 10) by Captain Austin Hudson, M.P. (Parliamentary Secretary to the Ministry of Transport), after which the Presidential Address will be delivered and a paper entitled "Directional Lighting by High and Low Pressure Lighting Gas Lamps" will be read by Mr. D. Chandler and Mr. A. J. Prestage (South Metropolitan Gas Company). After luncheon, on the invitation of the Gas and Electric Supply Industries. there will be a paper by Mr. A. J. Allbright (South Metropolitan Electric Light and Power Co., and South London Electric Supply Corporation, Ltd.) on "Developments in Electric Lighting in London." In the evening an inspection of the lights of London by motor coach will be arranged.

On the Wednesday (September 11) there are three papers in view, "Costs and Statistics of Street Lighting" (Mr. Ronald Parker); "An Analysis of Modern Views on Street Lighting and their Relation to Visibility" (Mr. F. C. Smith and Mr. K. F. Sawyer); and "Developments in Public Lighting in Germany" (Dr. Ing. Adolph, Berlin). Luncheon will be taken at the invitation of the chairman and directors of the Tottenham and District Gas Co., and in the evening the Association dinner and dance will take place.

On Thursday (September 12) there will be a paper in the morning on "The Importance of Kinematical Factors in Roadway Illumination," by Mr. L. J. Davies, and in the afternoon a visit by steamboat to the Port of London.

In addition several special events have been arranged for the benefit of ladies, such as a tour of inspection of Selfridge's Stores; visits to the Kodak Works at Wealdstone or the Greenford Depot of Messrs. Lyons' factories; and a drive to Virginia Water and Windsor Park.

Literature on Lighting

(Abstracts of Recent Articles on Illumination and Photometry in the Technical Press)

(Continued from page 190, June, 1935.)

I.—RADIATION AND GENERAL PHYSICS.

193. The Value of the Mechanical Equivalent of Light.

E. Lax. Das Licht, 76, April, 1935.

Until recently the value of the mechanical equivalent of light was quoted as lying between 0.00135 and 0.00153 watts per Hefner lumen. A more recent value, determined by Krefft and Pirani in 1932 for the Sodium D line, is 694 lumens per watt. In 1934 Wensel, Roeser, Barbrow, and Caldwell published results of a determination, using the radiation from a black body of the temperature of melting platinum. The value was 693 Hefner lumens per watt, or 0.001444 watts per Hefner lumen. S. E.

II.—PHOTOMETRY.

194. The Guild Flicker Photometer Head.

J. Sci. Inst., p. 169, May, 1935.

The conditions for securing accuracy in flicker photometers, as worked out by Ives, have been embodied in the construction of this instrument. Briefly, these conditions are: no dark period, field brightness is fairly high, small field of view surrounded by an illuminated field. The photometer head is illustrated diagrammatically, and a brief description is given. S. E.

195. The Guthnick Photoelectric Photometer.

E. J. Meyer. Zeits f. Instrumentenhunde, 55, pp. 111-116, March, 1935.

This instrument, fixed to an astronomical telescope, enables the measurement of the intensity of stars and their classification. The error is stated to be only about 0.5 per cent. of the order of magnitude of the star, as compared with 5 per cent. for the Gehloff photometer, a somewhat smaller error and for the surface photometer, and about 10 per cent. for the photographic method. Light from the image of the star in the telescope falls on the photocell, and the rate of charging of an electrometer is observed. Even with a telescope with only a six-inch objective lens or mirror, results accurate to within ½ per cent. are obtainable for stars of the fifth magnitude. The instrument is compact and weighs 25 lb. T. H. H.

196. A New Reflector Meter.

J. L. Michaelson. Gen. El. Rev., 38, pp. 194-196, April, 1935.

A description of a photoelectric reflection meter. Light is incident on the sample at 45 deg., and the amount reflected normally falls on a photocell. The reflecting power is determined for various parts of the spectrum by the use of a set of nine colour filters. All radiation longer than 700 μ is cut off by an additional filter. G. H. W.

197. A Simple Method of Heterochromatic Photometry.

R. A. Houston. Nature, 135, No. 3,424, p. 1,000, June 15, 1934.

Describes a modification of the Rumford photometer, which facilitates photometric settings in heterochromatic photometry. J. M. W.

198. Testing Colour-Constancy of Materials.

G. F. Bedford. El. Times, 87, p. 600, May 2, 1935.

Owing to the variability of sunlight intensities, it is very desirable to have an artificial source of constant value for use in fading tests. The apparatus described employs a 750 w. tungsten filament lamp, the lower part being made of quartz glass, and has a spectral distribution, said to be similar to sunlight. Specimens are subjected to 500,000 fc. illumination, and one hours' exposure is considered a sufficient length of time to decide whether the specimen is colour-constant. Photographs of the apparatus are given. W. R. S.

199. A New Selenium-Sulphur Rectifier Photoelectric Cell.

G. P. Barnard. Proc. Phys. Soc., 477, May, 1935.

Details are given for the construction of a rectifier photoelectric cell in which the sensitive surface consists of a mixture of selenium and sulphur. Measurements of the properties of experimental cells are recorded, and their relation to the construction of the cells discussed. S. E.

200. On the Use of Selenium Rectifier Photocells for Measurement of Radiation.

Rudolf Sewig. Phys. Zeits. 35, pp. 564-565, 1934.

It has been contended that deficiencies of these cells, such as deviations from proportionality especially at high illuminations, inertia and hystersis phenomena, make great care necessary in interpreting photometric results and render such cells useless for meteorological photometry. The author, however, claims that with due allowance for the above faults, the advantages of these cells (absence of saturation potential, lack of necessity for amplification, and a visibility curve similar to that of the eye) may be usefully employed in photometry even at the high illuminations encountered in meteorological work. T. B. H.

201. Photoelectric Control Apparatus.

M. Wilfart. Lux, pp. 48-49, April, 1935.

The author explains the operation of photoelectric relays and their application to various useful purposes such as the automatic control of lighting, as a counting mechanism, and in order to measure and limit the opacity of smoke issuing from a chimney. J. S. D.

202. Rapid Mathematical Methods for Trichromatic Colourimetry.

J. G. Holmes. Proc. Phys. Soc., 400, May, 1935.

The calibration of an instrument by measurement of an illuminant B is replaced by measurement of a suitable stable filter and the illuminant in actual use. A nomographic method of converting instrument readings to the C.I.E. basis is suggested, and a graphical method is given for conversion to terms of hue and saturation. Scales are given for conversion from the spectrophotometric curve of a coloured specimen to trichromatic coefficients with a series of illuminants on the C.I.E. basis. S. E.

III.—SOURCES OF LIGHT.

203. British Standard Specification for Tungsten Filament Electric Lamps (other than General Service Lamps).

No. 155, 1935.

This revised specification (formerly part of No. 161, 1932), refers to such special varieties of lamps as those for use in trains and trams, for navigation and for signals, and also double capped tubular lamps. In every case dimensions initial rating and life performance, and in certain instances also percentage allowance on life performance are specified. J. S. D.

204. The Use of Alloys for the Electrodes of Electric Discharge Lamps.

J. B. J. Marcel Abadie. R.G.E., vol. 37, No. 20, pp. 627-633, May 18, 1935.

Describes, with photographs and diagrams, researches into materials used as electrodes for electric discharge lamps, and enumerates possible applications of the lamps produced. W. R. S.

205. Lumiline Lamps.

Anon. Light, 4, No. 3, pp. 12-19, May, 1935.

Examples are given of present day American practice

in the use of tungsten filament tubular lamps, together with dimensional details of both lamp and holder.
C. A. M.

206. A New Light Source of High Efficiency.
Das Licht, 84, April, 1935.
This is essentially a super high pressure mercury vapour lamp. A small lamp only a few centimetres long and using 75 watts runs at a pressure of about 40 atmospheres and gives 40 lumens per watt. Another small lamp running at 160 atmospheres gives 65 lumens per watt, while a 10 k.w. water-cooled lamp running at 240 to 300 atmospheres gives about 90 lumens per watt. S. E.

207. New Sodium Vapour Lamp.
Anon. Elect., 114, p. 667, May 24, 1935.
Details with photograph and light distribution data are given for a new 70-80 w. sodium vapour lamp unit. The ease of assembly and lamp replacement are mentioned. C. A. M.

208. A New Type of Quartz-Mercury Lamp.
W. Ende. Elektrot Zeits, 55, pp. 853-857, 1935.
In this new type of mercury vapour lamp, many of the drawbacks of earlier forms are eliminated. It consists of a ultraviolet transmitting glass tube bent in the shape of an inverted U, with metallic oxide cathodes. The tube contains argon at a pressure of a few mm. and a few milligrammes of mercury. At the moment of switch on, an induction voltage is used momentarily to start the discharge through the argon. The mercury then takes up the discharge, the electrodes in the course of four minutes become red hot and emit electrons, and the glow discharge becomes an arc discharge of 2 amps. at 150 volts, with a very high ultraviolet output. This lamp remains much cooler than those of the older type, can be operated equally well by direct or alternating current. T. H. H

209. An Economy Indicator. An Apparatus for checking the correct operating voltage for incandescent lamps.
M. Grandjean. Bull. Soc. Elect., No. 52, pp. 413-417, April, 1935.
In this paper is described apparatus for determining the most economical operating voltage of an incandescent lamp. A voltmeter exhibits three scales indicating respectively lamp voltage, luminous output and operating costs, the two latter scales being determined by calculation as functions of the operating volts. The effect of the voltage on the life of the lamp, and hence on renewal costs, is taken into consideration. The correct voltage to ensure most economical working can be quickly ascertained. L. J. C.

IV.—LIGHTING EQUIPMENT.

210. Lighting Apparatus.
Various Authors. R. G. E., Vol. 37, No. 19, pp. 614-617, May 11, 1935.
Describes and illustrates various pieces of new lighting equipment shown at "La Foire Internationale d' Echantillons de Paris," including a portable lamp with alkaline battery, a focussing torch, a lamp equipped with metal reflector and an indirect lighting fitting. W. R. S.

211. New Shadowless Lighting Fitting for Surgical Operations.
Anon. Revue d'Optiqué, 14, No. 4, p. 160, April, 1935.
Describes a new form of shadowless operating theatre fitting, using a two-filament lamp, one filament being connected to the main supply, and the other, as a stand-by, to a 12 v. battery. An optical system is used which is claimed to avoid too great a contrast between the working area and the surround. An illumination of 5,000-6,000 lux from the 150-watt filament is claimed.
J. M. W.

212. Picture Lighting.
Anon. Elect., 114, p. 775, June 7, 1935.
Details with a photograph are given of a new fitting designed for the lighting of pictures and tapestry.
C. A. M.

213. Britain Tests Sheet-Steel Pole.
Anon. El. World, 104, p. 1070, December 8, 1934.
The article gives details of a sheet-steel pole, used extensively in Germany and Italy. The pole is made up of sections of elliptical tube, made from 1½ mm. and 2 mm. sheet steel, rolled, welded, pressed, and galvanised. By standardising twelve sections and selecting the appropriate range, several types of pole can be built up. The weight is less than ½ that of the equivalent wood pole, and, if damaged, only one section need be replaced. Photographs are given, and the results of tests made for British concerns. S. S. B.

V.—APPLICATIONS OF LIGHT.

214. New Developments in Illumination.
Anon. El. World, 105, pp. 1,341-1,343, May 25, 1935.
Photographs and a brief description are given of many recent developments in the field of illumination.
S. S. B.

215. The Relation between Illumination and Industrial Efficiency: (1) The Effect of Size of Work.
T. Weston. Joint Report of the Industrial Health Research Board and the Illumination Research Committee (D.S.I.R.), June, 1935.
The inquiry originated as a result of A. W. Beuttell's paper before the Illuminating Engineering Society ("An Analytical Basis for a Lighting Code") in 1934, and is based on the observation of Landolt, "broken rings," printed in black on matt art paper, by varying illumination. Six orders of magnitude of rings and gaps were studied. The results, which are of considerable importance, are assembled in diagrammatic form. Graphs connecting (a) performance and size, (b) performance and illumination, and (c) size and illumination (for a specified percentage performance) are presented. With objects subtending more than six minutes, performance is almost independent of illumination for values above 2 ft.-c. For objects of lesser magnitude, however, the effect is quite otherwise, the curve connecting performance and illumination continuing to rise, even after an illumination of 100 ft.-c. has been attained. J. S. D.

216. Improved Street Lighting by Glazed Street Surface.
L. Schnieder. Das Licht, 82, April, 1935.
Since wet asphalt road surfaces give a bright streak in between a street lamp and an observer, in which visibility is good, it is argued that street lighting would be improved if road surfaces were made of glazed asphalt. S. E.

217. Road Surface Brightness.
J. M. Waldram. El. Rev., Vol. CXVI., No. 3,003, p. 865, June 14, 1935.
The writer emphasises that the "effectiveness" of an installation is more important than the "efficiency." The effectiveness depends only indirectly upon the illumination falling on the road surface, but directly upon the brightness. The production of a high brightness on the road surface is discussed, and methods of measurement suggested. R. G. H.

218. The Lighting of Road Tunnels in Paris.
Das Licht, 81, April, 1935.
A circular road round Paris passes under the main outlets. One tunnel 252 metres long is illuminated during the day time by 242 lamps of 500 watt each. They are housed in chromium-plated reflectors, with prismatic front glasses.

A larger tunnel—495 metres, including the approach—has 130 mercury vapour lamps (425 watts) and 125 filament lamps (750, 1,000, and 1,500 watts). The largest filament lamps are used near the entrance, and the smallest near the middle of the tunnel. The fittings are built into the walls of the tunnel. In full sunshine all 255 lamps are on; but if the sky is overcast, each second lamp is used. Similarly, as daylight fails, more lamps are switched out, until by night only each eighth lamp is in use. The control is by photoelectric cells.
S. E.

219. Street Lighting.
Anon. Elect., 114, p. 652, May 17, 1935.
Details are given of an experimental street lighting installation, in which 100w. lamps, claimed to give brilliant, shadowless light without glare, are mounted on very low posts. See also Abstract No. 168, of June, 1935. C. A. M.

Recent Patents

(Abstracts of recent Patents on Illumination & Photometry.)

No. 426,222. "Improvements Relating to Aerodrome Lights."

Chance Brothers and Company, Limited, Hampton, W. M., and Norman, H. N. St. V., November 15, 1933.

This case covers an aerodrome flood light with a beam of 180 deg., which, when required as a rotary beacon, can be tilted about the longitudinal axis of the light beam or about an axis near and parallel thereto. Specification No. 346,915 is referred to.

No. 425,895. "Improvements Relating to the Head Lamps of Road and Other Vehicles."

Werry, W., July 22, 1933.

This case describes an arrangement of two head lamps mounted for simultaneous horizontal and vertical movement and linked together with a remote manual control so that their beams can be made to converge or diverge and may be dipped or elevated.

No. 427,111. "Improvements in and relating to Illuminating Systems Comprising Metal Vapour Electric Discharge Lamps Combined with Incandescent Lamps."

The British Thomson-Houston Company, Limited, Fenwick, C. E., Davies, L.J., and Tuppen, E. B., October 16, 1933.

High-pressure vapour discharge lamps will not easily ignite when hot. In a lamp system employing a vapour discharge lamp in proximity to an incandescent lamp, therefore, means are provided to reduce the heating of the vapour lamp by the incandescent lamp during periods when the power is extinguished and the vapour pressure is too high for initiation of the discharge. In one arrangement the vapour lamp is surrounded by a glass chimney, the draught through which cools the vapour lamp. The chimney also shields the vapour lamp from the convection set up by the incandescent lamp.

No. 427,254. "Improvements in or relating to Electric Lamps."

Downer, G. V., October 8, 1934.

According to this specification the light distribution from an electric lamp is improved by indenting the bulb towards the luminous element in an area where the radiation is stronger than necessary for optimum distribution, the sides of the indentation being formed at such an angle as to reduce the light transmitted there through by reflecting some of it in other and more useful directions. In one form the bulb is grooved or necked partly or wholly around in the plane containing a filament. The indented portion of the bulb may be roughened as by etching, sand-blasting or painting, to render it diffusing or opaque.

No. 427,462. "Improvements in Electric Discharge Lamps."

The General Electric Company, Limited, January 4, 1934. *(Convention, Germany.)*

This specification relates to discharge lamps of the negative glow type comprising luminescent material on or in either the envelope of the lamp or a separate screen in front of the negative glow inside or outside the envelope and filled with a rare gas and a substance emitting ultra-violet radiation. In such lamps heretofore the major portion of the light has come from the luminescent material, the rare gas filling only serving to facilitate the ignition of the lamp because the operating current was so chosen that, after starting, the pressure of the substance was such that only the discharge carried by it was visible. According to the invention the vapour pressure of this substance, which may be a metal vapour, is so low that the discharge through the rare gas is not suppressed entirely by that through the substance, and that a layer of light from the rare gas discharge appears on the cathode bordered by an edging of light of another colour from the discharge through the substance. The rare gas may be neon producing a red colour and the substance may be mercury, cadmium or manganesium, in quantity small enough to produce the desired low pressure, which requirement may be aided by low-operating current. The luminescent material may be zinc silicate or calcium tungstate.

No. 427,548. "Improvements in or relating to Lamps, particularly Vehicle Head Lamps."

Zikesh, K., September 19, 1932. *(Convention, Czech-Slovakia.)*

This specification covers an anti-dazzle lamp wherein a main light source and an auxiliary light source are utilised, and a colour filter is so arranged as to intercept and colour the light from each source directed upon the upper half of a mirror and a screen or reflector screens the auxiliary source from the lower half of the mirror and also from the front of the lamp, so that light emitted by the auxiliary source is directed through the filter upon the upper half of the mirror. Thus, when the unscreened or main source is operating, the upper part only of the lamp beam is coloured, but when the screened auxiliary source is operating the whole beam is coloured.

No. 427,813. "Improvements in or relating to Incandescent Electric Lamps."

Omega Lampworks, Limited, Jones, G. E., November 1, 1933.

According to this specification, the coiled filament of an incandescent electric lamp is arranged in a helix supported at its two ends by leading-in wires and at intermediate points by metal supports radiating from the stem. The stem of the lamp may be tubular, one leading-in wire passing up the stem and the other projecting from the foot or pinch. The invention is particularly applicable to long coiled filaments.

No. 428,118. "Improvements in and relating to Chimneys or Globes for Miners' Safety Lamps."

Dynamit-Actien-Gesellschaft Vormals Alfred Nobel and Co., June 27, 1933 *(Convention, Germany).*

According to this specification, a chimney or globe for miners' safety lamps consists of a difficultly breakable and combustible, colourless, and transparent highly polymerised organic compound, or mixtures of such, together with, if desired, softening agents and/or slightly volatile solvents, and/or artificial resins. For example, fireproof acetyl cellulose may be used. Other materials are given.

Lighting for Publicity

News from Czechoslovakia

We are indebted to Mr. Paul Grundfest (Dipl. Engineer), of Prague, for the following interesting account of publicity-lighting recently installed in that city.

The large publishing house of "Melantrich" has recently turned the front of its premises on the Wenzelplatz, the great boulevard of Prague, to good account for advertising on a large scale. The "Ceské Slovo," an important daily newspaper, has for some time been featured by an electric sign on the roof of the building. The wording of the sign, which is an exact reproduction of the title of the paper, is lit up successively as though the text were being written slowly with a pen; it is then extinguished, only to form again. The "writing" of the words occupies about eight seconds, and the number of individual switches is so selected as to obviate the impression of any jerkiness in operation. In spite of the fact that this sign is about ten years old, it has lost nothing of its effectiveness, thanks to excellent design and maintenance.

It was felt necessary, however, to provide illuminated signs for all the other newspapers and periodicals published by Melantrich. All the titles of the newspapers have accordingly been reproduced in their characteristic form in multi-coloured lighting tubes, the daily papers "A—Zet" and "Telegraf" being carried out in triple contour, and the remaining papers in single or double contours. (See Fig. 1.)

The outline of the building and its most outstanding architectural features are picked out in blue Neon tubes, whilst individual groups of words are interconnected by a line of white and red tubes. This selection of colours was based on the fact that white and red are the Czech national colours, and white-blue-red the Czech State colours, so that in this case both sets of colours appear in combination.

Latterly, another superscription, namely, the "Maly Oznamovatel" ("Little Advertiser") has been set up over the entrance to the building, and is joined up to the wording for the newspaper, "A—Zet," by a red line terminating in an arrow. The centre group of superscriptions also contain the advertisement for the "Bio Hvezda," the Cinema belonging to the Publishers.

The whole lay-out is operated by 74 transformers, with a capacity of about 15 KVA. In all, about 650 metres of tubing are mounted on this frontage, about 350 metres of which form the frame.

All the designs can be switched on or off in the course of one minute. At first the red outline in the "A—Zet" lights up, immediately followed by the blue inner line, whereupon the letters in the superscription "Telegraf" are switched on one by one in succession; finally, the other superscriptions are switched on groupwise. The red line from "A—Zet" to "Maly Oznamovatel" is designed in the form of a streak of lightning and consists of 16 separate tubes, which light up very rapidly at short intervals one after the other. The switchgear is operated by means of an electric motor. Four cam shafts are driven at different rotary speeds by means of worm gears and pinions, the switching element being mercury switch-tubes. Current intensities up to 60 amps., with high induction (power factor about 0.6) are used.

The installation, which was carried out by the largest light tube works in the country, the Ceskomoravská-Kolben-Danëk A. G., will be still further extended and supplemented.

Hitherto it has not been very usual in Czechoslovakia for the heavy industries to make use of light as a means of publicity. One of the first firms to use illuminated signs and illuminated buildings for popularising its most important products was the large "Poldihütte" Steel Works. The aspect of the front of its head office building in Prague has been entirely altered by an ample use of dark blue Neon tubes combined with the stainless steel known as "Poldi-Anticorro, produced by the firm itself. (See Fig. 2.)

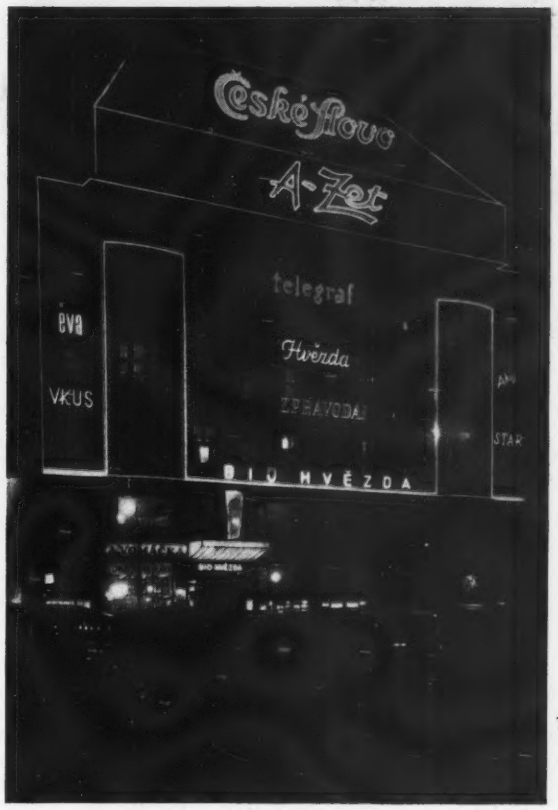


Fig. 1. The display of the "Ceské Slovo," and other publications, by aid of Neon tubes.

The glass of these Neon tubes is coloured dark blue in the mass and gives an excellent effect in daylight against the light background of "Anticorro" steel. The effect at night, however, is even more beautiful as will be seen from the illustration. Mr. Paul A. Kopetzky, an architect, of Prague, was responsible for the design.

The most important products of this world-wide firm are exhibited in four brightly illuminated windows (the lighting of which was planned by Mr. Grundfest), because it has been rightly realised that every passer-by, even if he may never become a direct buyer of the Works' raw materials, may, nevertheless, be a prospective buyer of many of the finished products marketed by other firms.

Fig. 2. Effective Publicity by means of Light, on behalf of the "Poldihütte" Steel Works.

CLIFTON SUSPENSION BRIDGE, illuminated by over 2,000 Osram lamps during the Silver Jubilee Celebrations —an effective G.E.C. installation.

The Highcliffe Hotel, Bournemouth, illuminated by 22 Philips Philora [Sodium electric discharge lamps,

Floodlighting for Hotels

The growing vogue of floodlighting for the exteriors of main hotels during conferences was well illustrated during the recent National Electrical Convention at Bournemouth. We show in the adjacent columns three installations, each utilising a different form of electric discharge lamps. The first of these, the Highcliffe Hotel, was illuminated by Philips's "Philora" Sodium 150-watt lamps, giving a soft amber glow. The hotel frontage (approx. 230 ft. wide and 60 ft. high) was treated by twenty-two lamps 14 ft. apart, the total consumption being 3.75 kw.

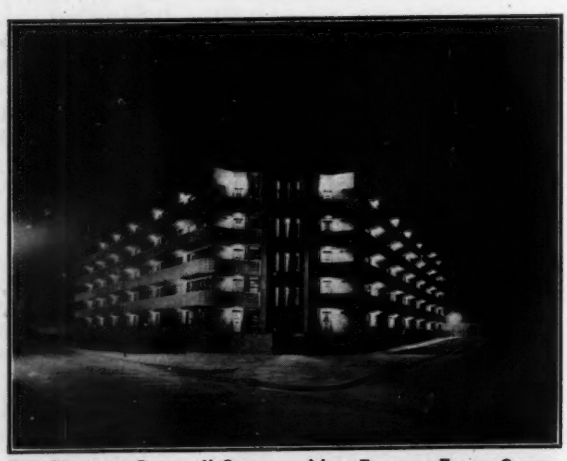
The Hotel Burlington, Boscombe, and likewise the Royal Bath Hotel and the Norfolk Hotel in Bournemouth were floodlighted by Mazda Mercra lamps in B.T.H. floodlight projectors; 128 projectors equipped with 400-watt lamps being thus used. These lamps, as is well known, give a greenish light.

In the case of the Chine Hotel, Siemens' 1,000-watt gasfilled (filament) lamps were used for the front of the building and a combination of 200-watt Siemens' red electric discharge tubes, and eight standard floodlights, with 200-watt Siemens' gas-filled (filament) lamps with amber screens was adopted for the south and west faces.

Other colour effects were illustrated in some of the G.E.C. installations, which included the Hermitage Hotel, illuminated by Osira h.p. mercury

The Hotel Burlington, Boscombe, floodlighted by Mazda Mercra lamps in B.T.-H. Floodlight projectors.

lamps, and the Whitehall Hotel, for which a combination of light and dark-blue Osira electric discharge lamps (giving an effect of brilliant moonlight) was used.



A "BRIGHTER POPLAR" SCHEME: NEW FLATS IN EMMET STREET

The accompanying night photograph, kindly furnished by the Borough Engineer of Poplar, Mr. Robert Illingworth, M.I.E.E., illustrates the pleasing effect of the special verandah-lighting by means of Holophane Bulkhead units which are built in flush with the under side of the canopy. The appearance of the flats at night has been the subject of much local comment.

The Chine Hotel, Bournemouth, floodlighted by Siemens 1,000-watt gas-filled lamps (Front) and Siemens Red Electric Discharge Tubes (South and West Faces).

MAZDA MERCRA LIGHTING IS MAKING THESE ROADS SAFER

Important main roads in various parts of the country have been made safer, both for traffic and pedestrians, by the installation of high intensity lighting with Mazda Mercra Lamps in BTH equipment.

Below we refer to recent and important contracts, which together with many earlier ones, and others not yet begun, indicate that where accident-proof lighting and economical operation are the chief considerations, BTH equipment is chosen.

PURLEY AND COULSDON U.D.C.
5 MILES—190 STANDARDS

In conjunction with the County of London Electric Supply Co., Ltd., we are supplying Mazda Mercra Lamps and BTH Diron Lanterns for lighting five miles of Brighton Road and Godstone Road. In addition, Mazda Gasfilled Lamps are being used for a further 71 miles of secondary street lighting.

BOROUGH OF LEYTON
5 MILES—184 STANDARDS

Mazda Mercra Lamps and BTH Diron Lanterns are being employed for the lighting of five miles of Lea Bridge Road and Grove Green Road.

MAZDA
MERCRA
REGISTERED TRADE MARK
LIGHTING

is installed at KINGSTON, WILLESDEN, ST. PANCRAS, BIRMINGHAM, BIRTLEY (Newcastle-on-Tyne), WOLVERHAMPTON, RUGBY, RAWTENSTALL, ST. ANNES, EDLINGTON, CARDIFF, MAIDSTONE, FOLKESTONE, LUTON, HARRATON, HARWICH, HOLYHEAD, HUDDERSFIELD, LEEDS, HALIFAX.

BTH LIGHTING ENGINEERS. BTH Lighting Engineers will be very pleased to collaborate with any Public Authority in the preparation of a scheme for the improvement of highway illumination. This advisory service is given without charge or obligation.

THE BRITISH THOMSON-HOUSTON CO., LTD., CROWN HOUSE, ALDWYCH, W.C.2

BTH

Garden Illumination

by

C. M. R. BALBI, A.C.G.I., A.M.I.E.E.

My wife, who is a keen gardener and an associate of the Royal Horticultural Society, asked me one evening during the winter months if I could do anything to illuminate the garden, as "what was the use of making everything beautiful, if for about half the the year I arrived home too late to feast my eyes on its delights?" My wife's attention must have been caught by the wonderful effects of flood-lighting to be seen on occasion in public gardens, illustrations of which have from time to time been seen in this journal. However, I had to explain to her that garden floodlighting is never likely to be a practical proposition for the small house owner, on account

Fig. 2. Concealed lighting of foliage by the waterside.

of the high initial cost of the fittings and running expenses. Then a few weeks after, I found the problem solved in a most effective way by an installation requiring but two or three low-intensity units which can be fitted into any garden scheme in such a way that even in daylight they are not unattractive.

The fittings are made as silhouettes of flowers such as tulips and animals such as storks and cockatoos, and for flower-bed lighting, are fitted with ground stakes, while for illuminating trees and bushes, clips are provided for attaching to branches.

The fittings are made of non-rusting metal and gaily painted on their front faces in the natural colouring of the flower or bird they represent. In each case a petal of a flower of the wing of a bird is punched out so that when a lamp is placed in a clip behind, some proportion of the light by secondary reflection lights up the front painted face of the figure as well as the surrounding foliage.

A 40-watt lamp is provided for each fitting, made with a special integral watertight holder and 9-ft. of cab-tyre cable, and, for the average size suburban garden, three or four of these low-voltage fittings provide all the illumination necessary to display to the best advantage all those specially interesting features possessed by every garden such as a well-grown rockery, fishpool or rose-walk, whereas to use a floodlight in a small garden would merely create harsh glare and white brilliance, and hence destroy all the artistic features which one wishes to enhance.

Every new house to-day seems to have its lily or fish-pond, and to illuminate this a fitting is provided

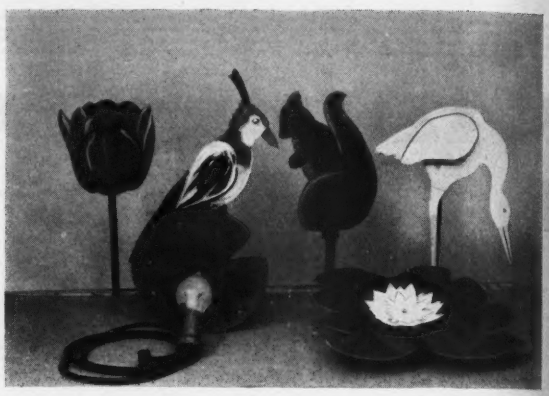


Fig. 1. Fittings simulating flowers and animals.

in the form of a floating water-lily leaf 9-in. in diameter, with a lamp attached underneath by a rubber sucker.

As is well known, fish are attracted by light, and after nightfall, when the light is switched on, one is able to see the various colours of the underwater plants and fish, which make a vivid picture.

The installation work of these fittings is made very simple by use of B. & T. connectors and enables an installation to be added to or the fittings changed about at any time.

The "Light Console"

The "Light Console" introduced by the Strand Electric and Engineering Co., Ltd., though resembling an organ console in appearance, is not a musical instrument. It is a really highly compact and ingenious stage switchboard, giving the operator perfect freedom to "play with light" by means of the

keys, altering intensity, duration, and colour at will —i.e., it is an application of the principles of organ control to stage lighting.

At the inaugural display on June 13, the young inventor, Mr. F. B. Bentham, showed how it could be applied to interpret "The Flying Dutchman," a nocturne, a ballet, and "hot jazz"—some of the colour-pictures and changes being of a very pleasing and original character. We have before us a detailed description of the apparatus, but those interested should apply to the firm for fuller data—or, better still, arrange to call at the Demonstration Theatre in Floral-street and see the Console in operation.

Floodlighting at the Tower of London Pageant and Tattoo

We are indebted to the Strand Electric and Engineering Co., Ltd., for the above effective night picture of the Tower of London Pageant and Tattoo, for the lighting of which they were responsible. This display formed a most successful feature of the Silver Jubilee Celebrations. It was mentioned in our last issue that 90 projectors, operating on the three-colour system, were erected on the front edge of the stand to furnish the requisite floodlighting.

Public Lighting in Oldham

The annual report of the public lighting superintendent in Oldham (Mr. Charles Worswick, who recently succeeded the late Mr. I. H. Massey) does not reveal any outstanding changes during the past year, and is chiefly noteworthy for the record of developments during the past eleven years, now arranged in effective diagrammatic form. The cost of lighting per head has remained practically stationary during the past three years, after the substantial drop (42.12d. to 36.39d.) in 1933, doubtless as the result of economies; and the candle power per head during the same period has only risen slightly, 8.1 to 8.3, as compared with 10.1 in 1932. Net expenditure has followed a similar course. Now that the financial position generally is a little easier, perhaps we may see the candle power per head rising once more to its former level. The number of lamps in use is, however, one quantity that has increased progressively without a check during the past twelve years.

SAY IT WITH LIGHT

The Directors of the Strand Electric and Engineering Co., Ltd. present to your notice the latest scientific method of light control

THE LIGHT CONSOLE

A single unit operates the entire installation and blends colouring in superb artistry. The Console is portable and may be plugged in various positions to suit requirements. Call and see a demonstration at our Private Theatre, 28, Floral Street, London, W.C.2

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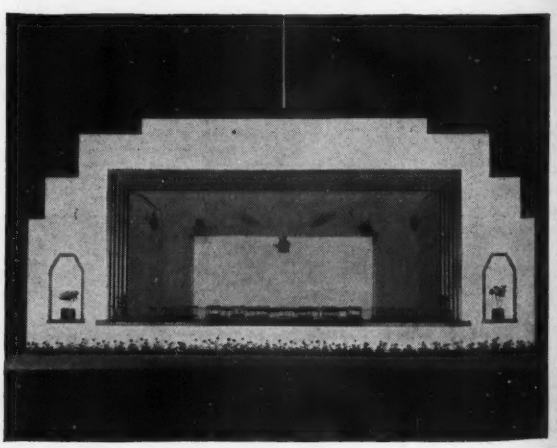
Telephone: TEMPLE BAR 7464 (6 lines) *Telegrams: SPOTLITE, RAND, LONDON.*

Lighting as an Aid to Passenger Transport

A paper on the above subject, recently read by Mr. S. J. Patmore before the Tramways, Light Railways and Transport Association, covered a wide ground. After dealing in detail with the interior lighting of buses, tramcars, and trolley vehicles the author found a word to say on such topics as penetration of fog, traffic-control signals, street lighting, illuminated advertising on vehicles, the creation of artificial traffic by means of lighting (Blackpool is a conspicuous example!) and aerial transport. The paper ("Electric Railway, Bus, and Tram Journal," June 7) contains some very effective illustrations. With some of Mr. Patmore's suggestions readers will find themselves in cordial approval; for example, his plea for the lighting-up of stopping-places of public vehicles, and his belief in the value of light in attracting public attention, and hence custom, for traffic concerns. (The Jubilee floodlighting had to be prematurely curtailed on account of its conspicuous success in this respect.) His exhortation to transport undertakings to enable young people to "Remember, remember the Fifth of November" on a more imposing scale may also find a sympathetic echo in some hearts.

Band Stand Illumination



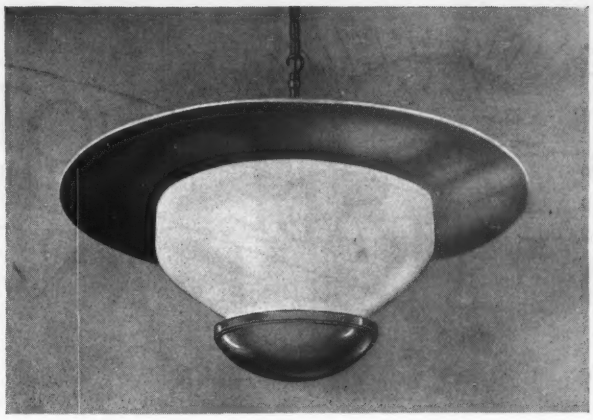
The Band Stand, recently opened by the Town Clerk at Hollycroft Park, Hinckley, has been effectively floodlit at night by means of BTH Type 'B' Floodlight Projectors, each fitted with a 400-watt Mazda Mercra Lamp. The equipment was installed by Mr. Clarence Goode, Electrical Contractor of Hinckley.

Another triumph for G.V.D.!

An interesting problem recently placed before the G.V.D. technical staff was the illumination of a weaving section of the Spondon Works of BRITISH CELANESE LTD.

The requirements were high-intensity lighting over and *into* the looms, and this unit was specially designed for the purpose. Results were entirely successful.

The special characteristics of the unit make it particularly appropriate for many other purposes where good light is required over a large area, particulary lofty halls, factories, etc., and outdoor lighting for docks, railways and public highways.



● *A specimen unit may be seen in our Showrooms, together with many other interesting applications of G.V.D. Patents. Please call, or write for literature.*

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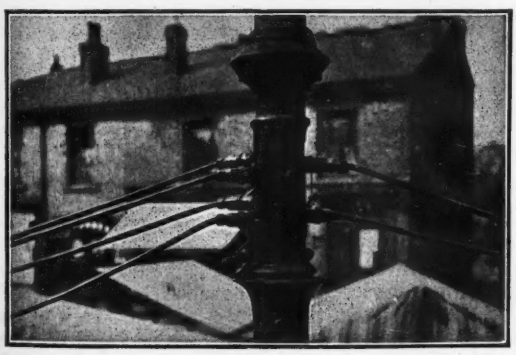

This illustration of part of a "NIPHAN" market lighting installation shows main feeding sockets fitted to a lamp standard. The "NIPHAN" system is adaptable for every type of temporary or portable lighting installation, and designs will gladly be submitted.

MARKET LIGHTING with the NIPHAN System . . .

FOR some years we have been collaborating with public lighting authorities in devising temporary lighting installations for market stalls. The picture shows part of a "NIPHAN" market job, in which 6 sockets, in conjunction with a fuse board, were mounted on a lamp standard, with plugs leading to 3-way tees and suspended through-sockets.

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TRADE NOTES AND NEWS

Holophane Refractor Lanterns

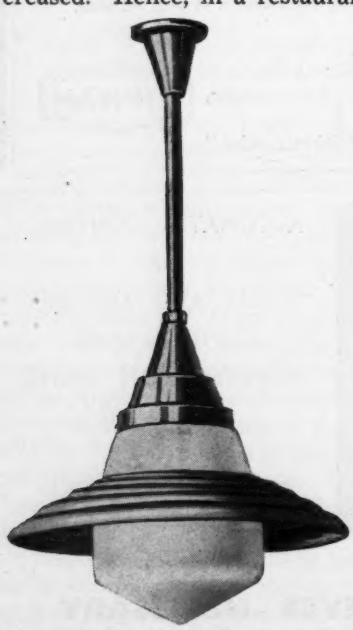
Novel types of Holophane Refractor Lanterns for both mercury and sodium electric discharge lamps are illustrated in a leaflet (No. 185) recently issued by Holophane, Ltd. The type intended for use with horizontal burning lamps is of somewhat unusual appearance, and gives a very wide lateral light distribution. A "Duo-Dome" lantern, for use with the 90-watt vertical burning sodium lamp, is also now available.

Another recent leaflet is devoted to the Holophane-Edgcumbe Auto-Photometers, which are available in two forms: Model "A," designed for street-lighting work, possesses several special features, such as the use of light-sensitive surfaces operating correctly at relatively wide angles, and the correction applied, within the instrument, for light of differing colour-value.

Harcourts "Reflecto" Diffusing Unit

A distinctive type of lighting fitting has been put on the market by Messrs. Harcourts, Ltd., which is particularly suitable for restaurants, cafés, quick-lunch bars, caféterias, etc. This "Reflecto" Diffusing Unit, here illustrated, is of distinctly modern design, without being aggressively so. It consists of an opal diffusing globe on the middle of which is rested an attractive silvered glass reflector, the whole being suspended from chromium plated metal work. The upper portion of the globe gives an even illumination of the ceiling.

The fitting gives efficient lighting at a moderate cost. In the size more generally suitable for restaurants, only a 200-watt lamp is required, and owing to the reflector, the "down" light is greatly increased. Hence, in a restaurant, brilliant illumination of the tables and immediate surroundings is readily obtained without glare. The "X-Radiant" reflector has the appearance of a series of white Neon rings when viewed from a sitting position, which is very effective in combination with the opal bowl. These units are very easy to keep clean, and where installed will give an hygienic effect.



The "Reflecto" Diffusing Unit.

The makers are willing, we understand, to arrange for a demonstration on the premises of anyone interested.

Another Jubilee Floodlighting Installation. The Duchy of Lancaster Offices on the Embankment floodlighted by Floodlighting and Fittings, Ltd., in conjunction with the Charing Cross Electricity Supply Co., Ltd. Ten 1,000-watt projectors and twenty-one 200-watt units were employed.

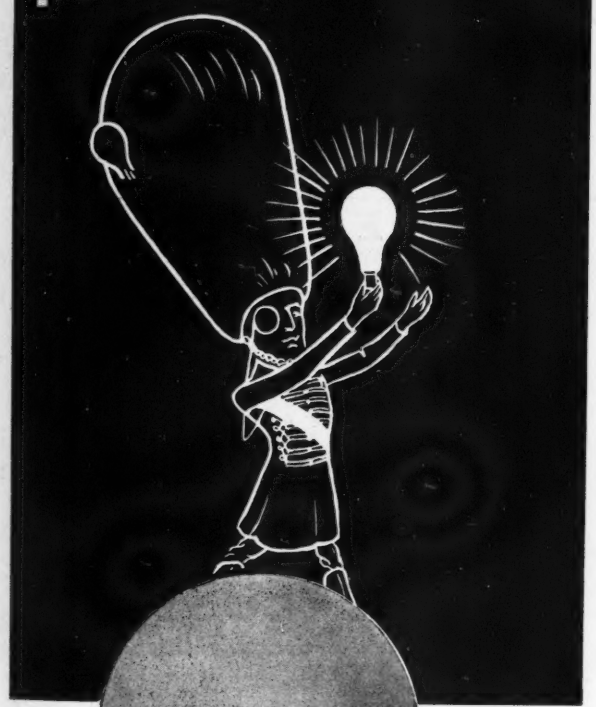
The Science of Seeing

An ingenious exhibit at the stand of the E.L.M.A. Lighting Service Bureau at the National Electrical Convention was the portable light-vision demonstrator, enabling persons to adjust the illumination so as to be comfortable for reading, and then to observe the value selected by the aid of a small light-meter. A statistical diagram, showing the results of tests made at the bureau on 112 persons, shows that the largest number (twenty) preferred about fifty foot-candles—whilst only three persons called for ten or under! The same idea can be applied to other tests; for example, the order of illumination preferred for the inspection of certain types of material. The bureau aims at obtaining records of as many as 10,000 people during the next few months.

Planning the Modern Sports Pavilion

Comfort in sports pavilions has to-day reached a high standard. Every club or organisation now aims at adequate artificial lighting, a proper supply of hot and cold water, and efficient arrangements for baths, such as are to be found in the fine pavilions on the new grounds of the Inland Revenue Sports Association opened by H.R.H. the Duke of York a few weeks ago. The planning of the building mentioned above is fully described in an illustrated booklet issued by the B.C.G.A., which shows the aid that can be rendered by gas.

Raising the lumens per watt



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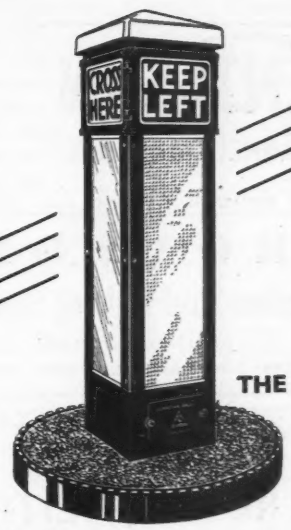

THE ARC ANGEL

Road users and traffic authorities may be divided upon other subjects, but all agree on the value of the ARC ANGEL Guide Post, which embodies the essentials of prominence and 24-hour visibility. Section 3 of the Catalogue contains full specifications of this and many other Gowshall G.A. Posts. May we send you a copy?

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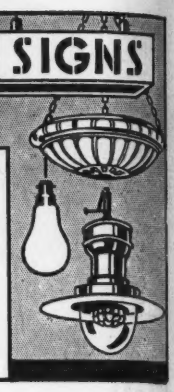

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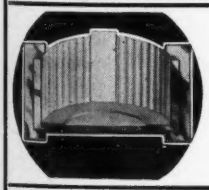
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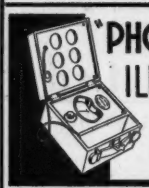
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N.B.—The numbers are those attached to individual entries in the Directory (See pp. 248-250).

Contracts Closed

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Royal Mail Lines, Ltd.—For part supply of Mazda lamps for the twelve months ending July, 1936.

SIEMENS ELECTRIC LAMPS AND SUPPLIES, LTD.

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Cryselco, Ltd.—New Glasgow Address

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WE have pleasure in announcing to our readers that we have entered into an arrangement to receive subscriptions for the French Journal "Lux" (La Revue de l' Eclairage). The subscription per annum is 30 francs, the approximate equivalent of which in English money is Seven Shillings and Six Pence (7/6).

"Lux" is the only French journal which specialises in all aspects of lighting; it is the official organ of the Association Francaise des Ingenieurs de l' Eclairage (equivalent to the Illuminating Engineering Society in France).

It furnishes a complete record of interesting developments in lighting in France and on the Continent. It is fully illustrated and in particular devotes a considerable number of its pages to Decorative Lighting.

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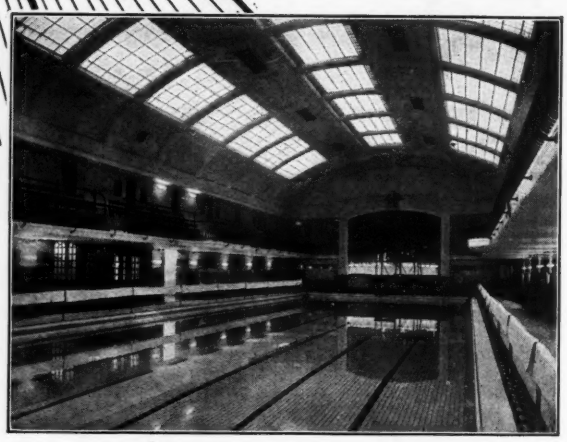

Night photo of West Ham Baths showing the brilliant and uniform lighting by the Holophane Laylighting System.

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